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水稻臺南5號、臺中184號及其混合品種與 F_2 羣體對稻熱病 (*Piricularia oryzae* Cav.) 抵抗性及產量之影響

鄧耀宗、邱善美、張鋼鎚、許東暉、黃眞生

一、緒　　言

水稻第一代的雜種優勢已有報告（5,8,15,16,17）*，但在經濟利用之先，仍有若干問題需予解決。因水稻爲一自花授粉作物，每花僅獲種子一粒，除非能利用細胞質雄不稔性（4），否則以人工雜交生產雜種第一代種子，由於生產成本過高，很難有推廣價值；而利用 F_2 或較晚世代，則其可能性較大。另一方面水稻雖具相當的雜種優勢，但比之於優良的推廣品種，就現有資料言，其增產程度並不十分顯著。據許氏等1969年的報告（8），在供試160個雜交組合中僅有 H24（臺南3號×臺中65號）及 H55（臺農38號×光復401號）兩組合優於對照品種臺南3號。Jennings（9）在1967年亦曾報告；在光照少，溫度高的熱帶性氣候下，水稻稻谷的雜種優勢將很難加以利用，但是葉面積指數（L A I），分蘗數，乾物重及株高在營養生長期的雜種優勢是非常明顯的。許氏等報告（8）亦證實 F_1 雜種在生育初期對耐寒性，抽穗期、株高、分蘗數等方面具有優勢。因此研究營養生長期間的雜種優勢之利用價值，亦不容忽視。

水稻營養生長期間，病蟲害的防治是最重要的課題之一，其中以稻熱病的問題最爲複雜。稻熱病病原菌 *Piricularia oryzae* Cav. 含有許多不同的生理小種（Physiologic races）（3）且具有很大的變異性（18）。新育成的抗病品種，經若干年栽培以後，往往逐漸變成感病品種（20）。爲解決這一類的問題，Jensen 等（2,10）建議使用混合品種；Van der Plank（19）建議採用具有 Horizontal resistance 的品種。前一種方法，嘉義農業試驗分所的試驗結果（22）認爲抗病品種佔50%以上的混合品種，有抑制稻熱病的效果。至於利用 Horizontal resistance 方面，目前正在搜集此種抗病的材料。

水稻抗稻熱病的遺傳行爲，大部份試驗結果顯示抗病對感病爲顯性。對不同生理小種的反應，抗病與感病雜交第二代的分離比，有3：1，9：7，15：1等不同的分離比例（1,67,13,14）。在田間抗病試驗方面，Kiyosawa等（11,12）報告：抗病程度不同的品種，田間與室內檢定的結果有相同的趨勢，但農林22號在田間的抗病力較室內爲强。因此本研究主要目的在探討雜種第二代與混合品種在田間對稻熱病的反應，其次探討稻熱病抗病性的遺傳力，並比較臺南5號，臺中184號及其混合品種與 F_2 羣體在發病地區之稻谷產量。 本試驗部分經費承農復會補助，文成後蒙萬所長雄斧正，一幷誌謝。

二、試驗材料與方法

臺南5號爲一中熟，高產的優良水稻品種，自1966年開始推廣後，栽培面積迅速增加，到1968年，其栽培面積已躍居全省首位。據臺灣省政府農林廳估計，在1969年臺南5號栽培面積佔蓬萊稻之45%（一、二期平均）（23）。雖然臺南5號普遍被農民採用，但是抗稻熱病的表現並不理想，尤以在苗栗、屏東等地比較嚴重。爲了改良臺南5號的抗病性，於1969年第一期作選擇一農藝特性與臺南5

*括弧內的阿拉伯數字代表引用文獻號碼。

號相近的抗稻熱病品種臺中184號爲親本，進行人工雜交，得雜種 F_1 種子約500粒，於1969年二期繁殖於臺北市之農試所農場。F_2 種子於1970年2月2日播種於臺北縣坪林黃舉皮寮試驗地，該處爲一山谷，四面環山，旁有一小河，相對濕度頗高，爲一理想的稻熱病發病地。供試品種除臺南5號（P_1）、臺中184號（P_2）與 F_2（$P_1 \times P_2$）之外，尚有一混合品種（M），即以臺南5號與臺中184號各半混合而成。3月13日將秧苗移植本田，採逢機完全區集設計（Randomized complete block design）重複兩次，每小區種植8行，每行25株，共200株。單本植，株、行距爲 20cm×25cm，小區與小區間種一行感病品種，每行之兩端各種兩株感病品種，感病品種係用臺中65號。

本田的施肥量爲 $N-P_2O_5-K_2O=240-54-60$ 公斤／公頃，施肥方法除磷、鉀肥料全量爲基肥外，氮肥分4次施用（20），茲將氮肥施用時期及用量列表如下：

項　　目	基　　肥	第一次追肥	第二次追肥	第三次追肥
施肥量（%）	25%	33%	25%	17%
施肥日期	3月12日	4月3日	4月20日	5月6日
日　　數	移植前1日	挿秧後21日	挿秧後38日	挿秧後54日

此外，爲繼續調查穗頸稻熱病，於6月4日（挿秧後83日）再施用40公斤／公頃的氮素肥料。

稻熱病的發病調查分四次進行，第一次係在5月19日，由於發病程度尚輕，僅調查第一重複各單株的病斑型，調查標準如下表：

病斑型	病斑型狀	病斑色澤
R	無病斑、小斑點或小病斑	褐色及至帶黑褐色
M	各種形狀的病斑	褐色病斑外圍有明顯邊緣中央部稍帶灰白色，其擴張範圍不越三小葉脈
S	大紡綞形或類似的形狀	病斑大型，中央部呈綠色或灰白色，邊緣呈褐色，有的病斑呈現水浸狀其外圍無一定的邊緣

第二次發病調查係在5月27日，調查項目除病斑型之外，尚調查罹病率（以單株爲單位）。葉稻熱病的罹病率參照水稻葉稻熱病罹病程度調查規準圖（20）。第三次調查係在6月4日，調查項目包括葉稻熱病的病斑型及罹病率。第四次調查係在7月11日，調查穗頸稻熱病的罹病率。穗頸稻熱病罹病率的調查方法係以單株爲單位，調查其被害穗數（一穗中有三枝梗以上罹病者算爲被害穗），再以下列公式計算罹病率。

$$罹病率=\frac{被害穗數}{單株全穗數}\times 100$$

罹病率0～10%爲極抗（HR），11～30%爲抗（R），31～50%爲中抗（MR），51～70%爲中感（MS），71～90%爲感（S），91～100爲極感（HS）。

本試驗未曾使用殺菌劑（Fungicide），僅使用EPN及γ-BHC等殺蟲藥劑（Insecticides）防治蟲害。於7月24日收穫，每小區收穫中間100株，計算產量。

各處理品種的平均罹病率係根據 Bliss 氏的轉百分數爲角度表換算爲角度（Degrees of angle）（21）計算而得，並用變方分析，再換算爲百分數。

遺傳力的估算是應用 Burton 氏的公式：

$$h_2=\frac{V_{F_2}-\frac{1}{2}(Vp_1+Vp_2)}{V_{F_2}}$$

三、試 驗 結 果

1.葉稻熱病

供試品種於2月2日播種後，日平均氣溫在12°~20°C之間，秧苗生長甚爲緩慢，40天的秧苗長僅6–10Cm 左右。在此期間除少數苗具有胡麻葉枯病（Brown spot）之外，未曾發現稻熱病病斑。移植後至4月上旬，氣温仍然在20°C左右，生長尙稱健全。4月中旬以後，氣温逐漸上升，到5月上旬，日平均氣温已達24～27°C，稻熱病病斑逐漸顯現。因第一重複先發病，且比較嚴重，故5月19日（挿秧後67日）行第一次發病調查時，僅調查第一重複，結果如表1.。

表1. 臺南5號、臺中184號及其混合品種與F_2羣體於移植後67日之葉稻熱病反應。

Table 1. Reactions of Tainan 5. Taichung 184, their mixed variety and F_2 population to rice leaf blast at 67 days after transplanting (DAT).

品種 Variety	病斑型 Lesion type R	M	S	調查株數 Total no. of plants observed
臺南5號 Tainan 5	—	18 (37.50) *	30 (62.50)	48
臺中184號 Taichung 184	47 (95.90)	2 (4.08)	—	49
混合品種 Mixed variety	89 (44.50)	22 (11.00)	89 (44.50)	200
第二代雜種 F_2 population	104 (54.16)	0	88 (45.83)	192

* 括弧內數字爲各該品種病斑型之百分比。

(Numbers in the parenthesis are the percentage of the lesion type for each variety.)

表1顯示臺南5號在該地爲一感病品種，臺中184號則爲抗病品種。混合品種的反應，抗病與感病約爲1：1之比；較諸兩個原品種單獨種植之平均值，則混合品種之感病植株有稍多之傾向。F_2（臺南5號×臺中184號）的抗稻熱病反應，抗病與感病約爲9：7之比。

第二次發病調查在挿秧後75天（5月27日），病情已相當理想，仍調查葉稻熱病病斑型與發病率，結果分列於表2及圖1。

表2. 臺南5號、臺中184號及其混合品種與F_2羣體於移植後75日之葉稻熱病反應。

Table 2. Reactions of Tainan 5, Taichung 184, their mixed variety and F_2 population to rice leaf blast at 75 DAT.

品種 Variety	病斑型 Lesion type R	M	S	調查株數 Total no. of plants observed
臺南5號 Tainan 5	—	1 (2.00)	49 (98.00)	50
臺中184號 Taichung 184	38 (76.00)	11 (22.00)	1 (2.00)	50
混合品種 Mixed variety	44 (22.00)	25 (12.50)	131 (65.50)	200
第二代雜種 F_2 population	63 (31.65)	44 (22.11)	92 (46.23)	199

由表 2 可看出本次之調查結果比第一次者已有顯著變化：臺南 5 號感病植株由62.5%變爲98%，即增加35.5%；臺中184號則僅增加 2 %；混合品種增加21%，而 F_2 羣體僅增加0.4%。再就罹病率的分佈圖（圖 1）觀之，混合品種比臺南 5 號抗病，F_2 羣體比混合品種抗病；但無論 F_2 羣體或混合品種，其抗葉稻熱病的程度均比不上抗病品種臺中184號。

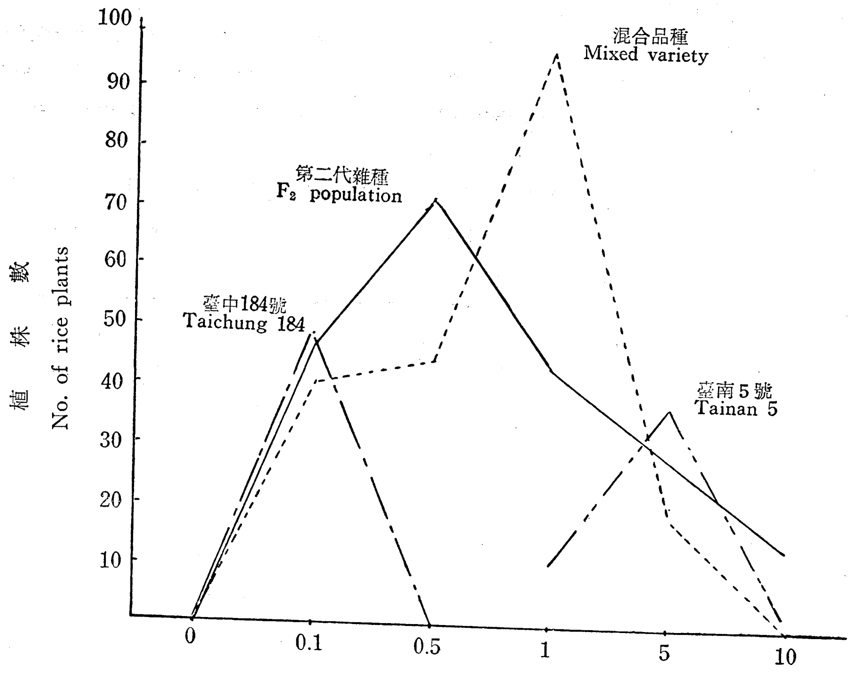

圖1. 臺南 5 號、臺中184號及其混合品種與 F_2 羣體於移植後75日之葉稻熱病罹病率。

Fig 1. Degrees of rice leaf blast for varieties Tainan 5, Taichung 184, their mixed variety and F_2 population at 75 DAT

第二次發病調查之後，葉稻熱病稍有恢復的趨勢。於 6 月 4 日（挿秧後83日）行第三次發病調查，玆將其病斑型與罹病率分列於表 3 與圖 2 。

表3. 臺南 5 號、臺中184號及其混合品種與 F_2 羣體於移植後83日之葉稻熱病反應。

Table 3. Reactions of Tainan 5, Taichung 184, their mixed variety ant F_2 population to rice leaf blast at 83 DAT

品種 Variety	病斑型 Lesion type R	M	S	調查株數 Total no. of plants observed
臺南 5 號 Tainan 5	—	3 (6.12)	46 (93.87)	49
臺中 184 號 Taichung 184	33 (70.21)	11 (23.40)	3 (6.38)	47
混合品種 Mixed variety	59 (29.50)	16 (8.00)	125 (62.50)	200
第二代雜種 F_2 population	83 (41.70)	18 (9.04)	98 (49.24)	199

表3顯示混合品種與臺南5號有同一趨勢，即感病的百分率已下降，而 F_2 羣體與臺中 184 號之感病百分率則尚在緩慢上升中。在罹病率方面亦可看出臺南5號、混合品種與F_2羣體病勢恢復的現象（圖2），F_2 羣體的高峰自移植後75日的0.5%移至移植後83日的 0.1%；混合品種及臺南5號亦有恢復的趨勢，但臺中184號則還在緩慢的發病中。

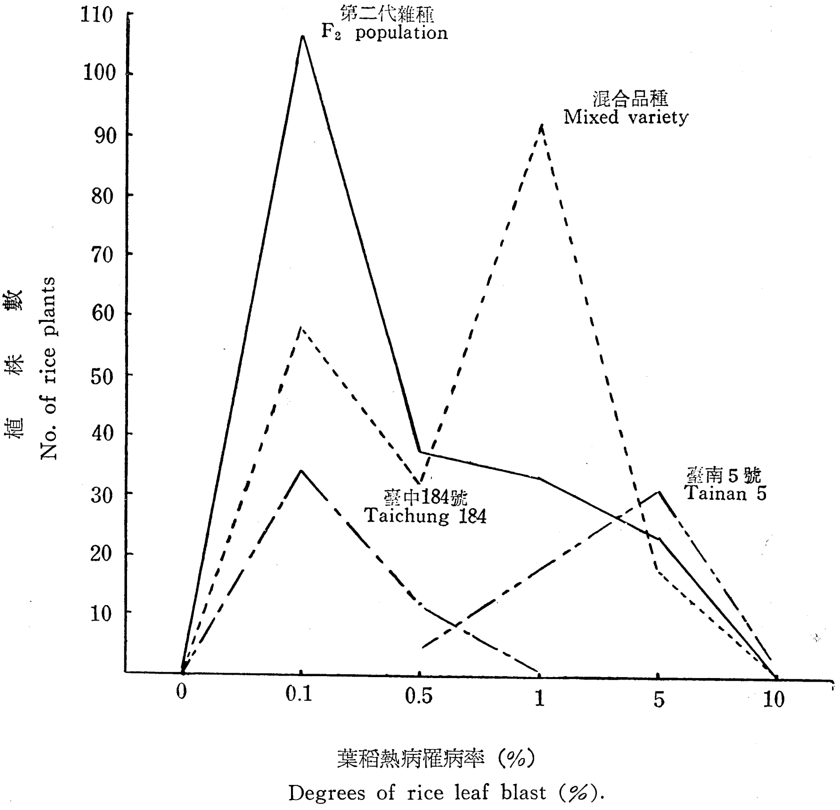

圖2. 臺南5號、臺中184號及其混合品種與 F_2 羣體於移植後83日之葉稻熱病罹病率

Fig. 2. Degrees of rice leaf blast for varieties Tainan 5. Taichung 184, their mixed variety and F_2 population at 83 DAT

2. 穗頸稻熱病

穗頸稻熱病係於乳熟期（120 DAT）調查，第一重複的罹病率均比第二重複爲嚴重，且各品種處理間兩重複具有相同的趨勢（表4）。臺南5號抗穗頸稻熱病能力仍較臺中184號爲弱，臺中184號則爲極抗的品種。混合品種的罹病率雖介於兩原品種之間，但比臺南5號及臺中 184 號兩者罹病率的平均數爲高。這項結果表示臺南5號與臺中184號以 1：1 的種子量混合對穗頸稻熱病沒有減低罹病的效果。而 F_2 羣體對穗頸稻熱病的抗病力顯然比混合品種爲强。

圖3顯示臺南5號與臺中184號對穗頸稻熱病的反應都以極抗病（HR）爲高峰，但臺南5號的分佈較廣，自極抗（HR）到感病（S）。混合品種與 F_2 羣體對穗頸稻熱病的反應，雖亦以極抗爲高峰，但在中抗（MR）與中感（MS）方面，F_2羣體表現得比混合品種爲抗病。

表4. 臺南5號、臺中184號及其混合品種與 F_2 羣體之穗頸稻熱病平均罹病率（移植後120日）

Table 4. Means of neck blast (%) of Tainan 5, Taichung 184, their mixed variety and F_2 population (at 120 DAT).

品種 Variety	穗頸稻熱病罹病率 (%) % of neck blast of rice		平均值 Means
	第一重複 (Rep. I)	第二重複 (Rep. II)	
臺南5號 Tainan	25.5 (47) *	23.3 (50) *	24.40 a* *
臺中184號 Taichung 184	4.5 (46)	1.7 (47)	3.10 d
二品種平均 Average	13.2	9.7	11.45 (bc)
混合品種 Mixed variety	17.9 (198)	10.8 (193)	14.33 b
第二代雜種 F_2 population	10.0 (199)	5.8 (200)	7.90 c

*調查植株數 (No. of plants observed)

**平均值後之英文字母不相同者，表示在5%機率下差異顯著。

(Means followed by the different letter differ significantly at 5% level of probability.)

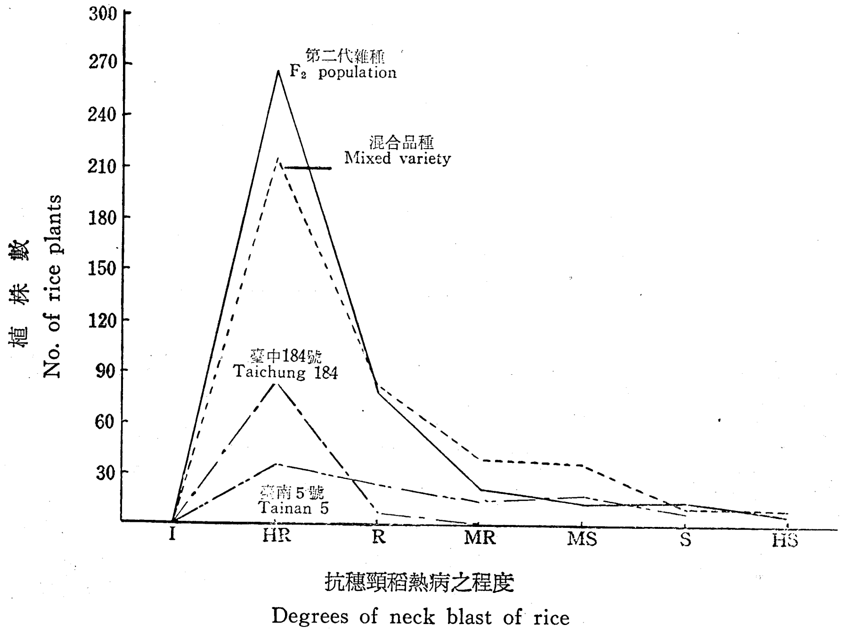

圖 3. 臺南5號、臺中184號及其混合品種與F_2羣體之穗頸稻熱病。

Fig. 3. Reactions of Tainan 5, Taichung 184, their mixed variety and F_2 population to neck blast of rice

3. 稻谷產量

本試驗首要目的在瞭解 F_2 羣體的抗病力，肥料的施用是爲了促進稻熱病之發生，氮肥 (N) 施用量高達280公斤／公頃，故各品種處理於乳熟期發生嚴重的倒伏。玆將各試區稻谷產量列於表 5 。

表5. 臺南 5 號、臺中184號及其混合品種與F_2羣體之稻谷產量（公斤／公頃）。

Table 5. Grain yields of Tainan 5, Taichung 184, their mixed variety and F_2 population (kg/ha)

品種 Variety	重複 Replication I	重複 Replication II	平均值 Means
臺南 5 號 Tainan 5	2400	2640	2520 c*
臺中 184 號 Taichung 184	4070	4830	4450 a
混合品種 Mixed variety	3090	3480	3285 b
第二代雜種 F_2 population	3360	3720	3540 b

*平均值後之英文字母相同者，表示在 5 %機率下無顯著的差異。

(Means followed by the same letter do not differ significantly at 5% level of probability.)

雜種第二代產量雖不及抗病品種臺中 184 號高，但比臺南 5 號增產40%，比混合品種增產 8 %，比其兩親本的平均產量增加 1.6 %。雜種第二代兩個重複的平均產量與混合品種相比較，雖然差異不顯著 (表5) ，可是第一重複與第二重複具有相同的趨勢，可見雜種第二代有較高的生產潛力 (Yield potential) 。

4. 稻熱病抗病性之廣義遺傳力

廣義的遺傳力估算是利用各時期的罹病率計算而來。葉稻熱病的抗病性遺傳力是以 5 月27日調查的資料估算，結果 $h_2 = 94.24\%$，穗頸稻熱病的抗病性遺傳力爲83.18%。可見稻熱病的抗病性遺傳力頗高。

四、討　　論

就病斑型而言：初期葉稻熱病調查結果，混合品種有半數稻株抗病，半數感病，表示混合品種不因混合抗病與感病品種而減少葉稻熱病發生的現象。F_2 羣體則約爲 9 (抗病) ：7 (感病) 之比。一星期以後 (75 DAT) ，臺南 5 號與混合品種的感病型 (S) 病斑急速增加，而臺中 184 號與 F_2 羣體則僅增加 M 型病斑 (表 6) 。再一星期以後(83 DAT)，S 型病斑在臺南 5 號與混合品種已有減少的現象，但在臺中184號與 F_2 羣體尙以極緩慢的速度增加； M 型病斑在臺中184號與臺南 5 號略有增加，而混合品種及 F_2 羣體則反而減少。至於 R 型病斑，在混合品種與 F_2 羣體中顯著地增加，表示混合品種與雜種第二代的恢復能力較强。

表 6. 水稻臺南 5 號、臺中184號及其混合品種與 F_2 羣體自移植後67日到83日對葉稻熱病抗病力之變化。

Tadle 6. Changes of reactions of Tainan 5, Taichung 184, their mixed variety and F_2 poulation to rice leaf blast from 67 DAT to 83 DAT.

調查日期 Date of observation	品種 Variety	病斑型百分率 % of lesion type R	M	S
5月19日 May 19 (67DAT)	臺南 5 號 Tainan 5	—	37.50	62.50
	臺中 184 號 Taichung 184	95.90	4.08	—
	混合品種 Mixed variety	44.50	11.00	44.50
	第二代雜種 F_2 population	54.16	—	45.83
5月27日 May 27 (75DAT)	臺南 5 號 Tainan 5	—	2.00	98.00
	臺中 184 號 Taichung 184	76.00	22.00	2.00
	混合品種 Mixed variety	22.00	12.50	65.50
	第二代雜種 F_2 population	31.65	22.11	46.23
75 DAT與67 DAT病斑型之差	臺南 5 號 Tainan 5	—	−35.50	+35.50
	臺中 184 號 Taichung 184	−19.90	+17.92	+2.00
	混合品種 Mixed variety	−22.50	+1.50	+21.00
	第二代雜種 F_2 population	−22.51	+22.11	+0.40
6月4日 June 4 (83DAT)	臺南 5 號 Tainan 5	—	6.12	93.87
	臺中 184 號 Taichung 184	70.21	23.40	6.38
	混合品種 Mixed variety	29.50	8.00	62.50
	第二代雜種 F_2 population	41.70	9.04	49.24
83 DAT與75 DAT病斑型之差	臺南 5 號 Tainan 5	—	+4.12	−4.13
	臺中 184 號 Taichung 184	−5.79	+1.40	+4.38
	混合品種 Mixed variety	+7.50	−4.50	−3.00
	第二代雜種 F_2 population	+10.05	−13.17	+3.01

葉稻熱病 S 型病斑的變化可以由圖 4 看出。從移植後67日到83日期間，四品種處理的變化情形可區分爲兩類：即臺南五號與混合品種先急速的增加，然後緩慢的降低；臺中 184 號與 F_2 羣體則一直在以緩慢的速度增加。據 Van der Plank(19)解釋，前一類屬感病型，後一類屬抗病型。再就葉稻熱病的罹病率而言，在移植後75日調查的資料顯示：F_2 羣體的平均罹病率爲其雙親罹病率平均值 (MP) 之88.74%；而混合品種的平均罹病率則爲 MP 的 78.96%。移植後83日的資料：F_2 羣體的罹病率爲MP的64.59%，混合品種則爲 MP 的77.32%。這些結果表示 F_2 羣體與混合品種的平均罹病率均比臺南 5 號與臺中 184 號的平均罹病率爲低，即有抑制葉稻熱病蔓延的效果，與趙氏等 (22

）的報告相同。再以 F_2 羣體與混合品種的平均罹病率相比較：在移植後75日時，F_2 羣體比混合品種增加12.38%；在移植後83日時，F_2 羣體反比混合品種減少16.47%，表示 F_2 羣體對葉稻熱病的恢復能力比混合品種強。

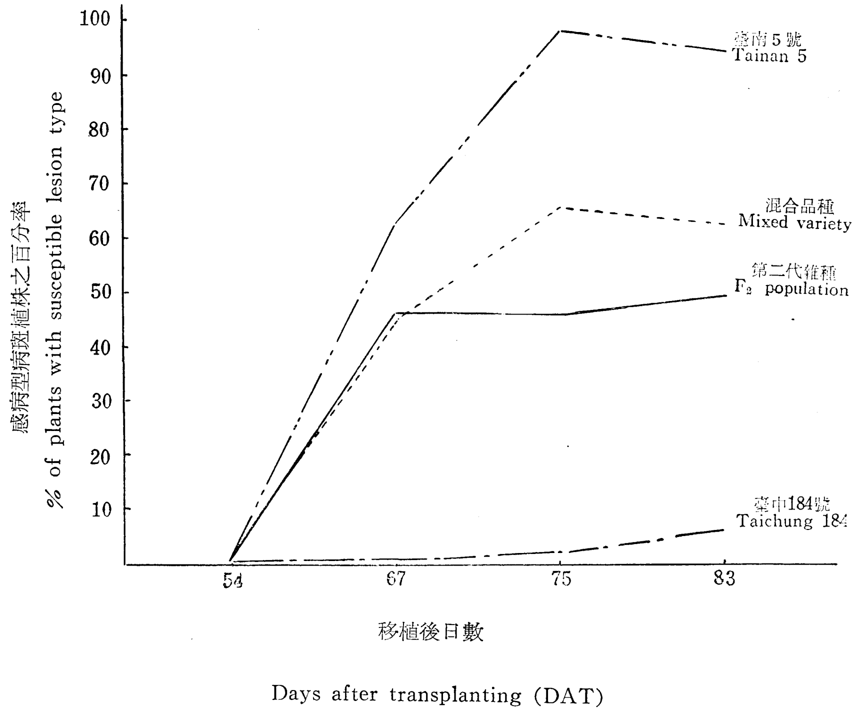

圖 4. 水稻臺南 5 號、臺中184號及其混合品種與 F_2 羣體自移植後54到83日感染型病株數之變化。

Fig 4. Changes of percentage of susceptible lesion type in rice varieties Tainan 5, Taichung 184, their mixed variety and F_2 population from 54 DAT to 83 DAT

就穗頸稻熱病的罹病率分析，表 4 顯示混合品種的平均罹病率比 MP爲高。爲了進一步瞭解臺南 5 號與臺中184號在混合品種中的發病情形，根據稻稃尖色的特性（臺南 5 號無色，臺中184號有色），選第二重複的混合品種試區（Ⅱ-M）分別調查穗頸稻熱病的發病率，以與臺南 5 號（Ⅱ-P_1）及臺中184號（Ⅱ-P_2）單獨栽植區之發病率比較。表 7 顯示臺南 5 號的穗頸稻熱病罹病率，不因與抗病品種臺中184號混合栽植而降低其罹病率；相反的，Ⅱ-M 區的臺南 5 號之平均罹病率比 Ⅱ-P_1 者爲高。但 Ⅱ-M 區的臺中184號 之罹病率比 Ⅱ-P_2 者爲低。表示以臺南 5 號與臺中 184 號混合栽培，不能抑制臺南 5 號之穗頸稻熱病的發生。就穗頸稻熱病發病情形而言，雜種第二代則頗具利用價值。

表 7. 臺南 5 號、臺中184號與其混合品種對穗頸稻熱病反應之比較。

Table 7. Comparison of reaction of pure stand Tainan 5, Taichung 184 with their mixed variety to neck blast

品種 Variety	原試區 Original plot		抗病程度 Degrees of resistance HR	R	MR	MS	S	調查株數 Total no. of plants	*平均值 Means (%)
臺南五號 Tainan 5	臺南 5 號 Tainan 5 (Π—P_1)	植株數 No. of plants	18	14	5	9	4	50	23.30%
		(%)	(36)	(28)	(10)	(18)	(8)	(100%)	
	混合品種 Mixed variety (Π—M)	植株數 No. of plants	30	43	24	11	3	111	27.80%
		(%)	(27.02)	(38.73)	(21.62)	(9.90)	(2.70)	(99.97%)	
臺中184號 Taichung 184	臺中184號 Taichung 184 (Π—P_2)	植株數 No. of plants	29	16	2			47	1.70%
		(%)	(61.70)	(34.04)	4.25			(99.99%)	
	混合品種 Mixed variety (Π—M)	植株數 No. of plants	81	1				82	0.12%
		(%)	(98.78)	(1.21)				(99.99%)	

*穗頸稻熱病平均罹病率

(Means of percentage of neck blast.)

根據產量試驗（表 5）與稻熱病發病的資料可知：在稻熱病發生猖獗地區，抗病力爲決定水稻稻谷產量的一個主要因素。臺南 5 號雖爲高產品種，受稻熱病爲害後，其產量僅及抗病品種臺中 184 號之56.6%；而混合品種與雜種第二代因抗病力增强，其產量分別比臺南 5 號增加30%及40%。就實用價值而論，育成雜種第二代（F_2）甚至第三代（F_3）所需時間很短，只要把雜交組合選定，經1～2年後即可推廣。在稻熱病發生比較嚴重的地方，甚至可以配合藥劑防治，其效果可能更加明顯。雜種第二代在無病地區的產量待作更進一步的試驗。

五、摘　　要

以臺南 5 號與臺中 184 號爲親本的雜種第二代及混合品種，在田間自然病圃進行抗稻熱病檢定，結果摘要如下：在抗葉稻熱病方面，就病斑型調查結果而言，混合品種較兩品種單獨栽培的平均值有偏向感病的趨勢；而雜種第二代則較混合品種抗病，尤其在最高分蘖期更爲明顯。就葉稻熱病的罹病率而言，混合品種的罹病率比其兩品種單獨栽培的平均罹病率爲低，而雜種第二代比混合品種抗病。雜種第二代感病後之恢復能力亦較混合品種爲强。

在抗穗頸稻熱病方面，混合品種的穗頸稻熱病罹病率比其兩品種單獨栽培之平均罹病率爲高。雜種第二代抗穗頸稻熱病的能力比混合品種爲强。至於稻谷產量方面，以抗病品種臺中 184 號的產量爲最高，其次分別爲雜種第二代與混合品種，感病品種臺南 5 號之產量最低。廣義的遺傳力估算，抗葉稻熱病爲94.24%；抗穗頸稻熱病爲83.18%。

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FIELD REACTIONS OF RICE VARIETIES, TAINAN 5, TAICHUNG 184, THEIR MIXED VARIETY AND F2 POPULATION TO RICE BIAST AND GRAIN YIELDS.

by

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Summary

Tainan 5, a high yielding rice variety but susceptible to blast was crossed with a blast resistant variety, Taichung 184, in the spring of 1969, in order to study the reaction of F_2 population to rice blast under field condition. Pure stand Tainan 5, Taichung 184, and their mixed variety were also used in comparison with the F_2 population in this experiment. Randomized complete block design with two replications was used. In the spring crop of 1970, all experimental materials were transplanted in the field at a spacing of 20 cm×25cm with single plant per hill. The plot size was $2 \times 5m^2$ and 200 plants were planted in each plot. The amount of nitrogen applied was 280 kg/ha. Types of the leaf blast lesions, percentage of the leaf blast, percentage of neck blast, and the grain yield were recorded and analyzed.

The mixed variety, based on the types of leaf blast lesions, did not show any favorable trend with respect to rice blast resistance as compared with reactions of the mid-parent (MP). On the other hand, the mixed variety showed more resistant to leaf blast than MP, with regard to the percentage of leaf blast. The F_2 population, however, showed more resistant to leaf blast than mixed variety based both on types of leaf blast lesions and percentage of blast. Moreover, the rate of leaf blast increased rather rapidly in mixed variety, than in the F_2 population. The F_2 population also showed more vigorous for recovering from leaf blast.

In this test, Tainan 5 was resistant, and Taichung 184 was highly resistant to neck blast. The mixed variety showed more susceptible to neck blast than MP, but the F_2 population showed relatively resistant to it. Since the color of apiculus could be used as the marker to distinguish Tainan 5 and Taichung 184, the mixed variety was then separ-

ated into their two component varieties for comparison of neck blast resistance with their original varieties grown as pure stand. The data in Table 7 showed that there was no significant difference between pure stand Tainan 5 and Tainan 5 in the mixed variety. Therefore, it is clear that there was no evidence for isolation mechanism in the mixed variety, so far as the neck blast reactions is concerned.

It is clearly indicated that the grain yield closely correlated with the degree of blast resistance in the test. Tainan 5 showed the lowest yield despite its high yielding capacity. The mixed variety and the F_2 population gained 30% and 40% of grain yield more than that of Tainan 5 respectively.

The broad sense of heritability of rice blast resistance was estimated. It was 94.24% for leaf blast and 83.18% for neck blast.

RELATIONSHIP BETWEEN SEEDLING LENGTH AND PLANT HEIGHT AND ITS IMPACT ON THE SELECTION OF SHORT PLANT IN RICE*

W. L. Chang

Heavy fertilization has been an effective way for increasing rice grain yields. However, increased application of fertilizers generally accompanies with the increase of plant height (Chang, 1968). Inasmuch as plant height is a major factor in determining varietal resistance to lodging (IRRI, 1966), tall plants appear more susceptible to lodging. It has been clearly demonstrated that lodging causes an appreciable losses in yields of rice (Jennings and Sornchai, 1964). Thus, significant increase of rice yields through heavy fertilizer application appears unlikely before considerable improvement in lodging resistance has been made. It is quite natural, therefore, that the development of short stature varieties with favorable lodging resistance and nitrogen responsiveness has constituted the major objective in our rice breeding program.

Selection for plant height is traditionally done in the paddy field when rice plant are fully matured. Since plant height is mostly controlled by a single pair of alleles and a few modifiers, with tall stature being either completely or incompletely dominant over short one (Aquino and Jennings, 1966 ; Chang et al., 1965 ; IRRI, 1965, 1966), rice plants in the F_2 population of the crosses involving the tall and the short varieties are expected to segregate into either 3 tall: 1 short or 1 tall: 2 intermediate: 1 short ratio. Thus, when selection for plant height is made in F_2 population, a majority of the taller plants will be eventually discarded, resulting in the waste of time, land, and capital inputs. However, if the potentially tall plants can be properly eliminated at the seedling stage, more space in the paddy field can be made available for the transplanting of short plants. As a result, chances of obtaining short plants combined with other desirable traits can be greatly increased.

The objectives of this investigation were (1) to measure the relationship between seedling length before transplanting and plant height among rice varieties of different plant types, (2) to determine the possibility for selecting short plants based on the length of seedlings in the nursery, and (3) to estimate the heritability values of seedling length in some F_2 populatoins of rice.

MATERIALS AND METHODS

A total of 95 and 94 rice varieties were randomely selected in the first and the second crops of 1969 respectively for the calculation of correlation coefficients between seedling

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length and plant height at various growing stages. In the first crop, there were 19 varieties of indica type and 76 varietes of japonica one whereas in the second crop, the varieties consisted of 17 indica type and 77 japonica one. Both tall and short stature varieties were included in each type of rice. The length of seedling was measured on the day of transplanting by using seedlings of representative growth of each variety. Plant height was measured once every 30 days from transplanting up to the full maturity of rice. Twenty measurements were made for each variety in both seedling length and plant height and the average values of both characters were used for the calculation of the simple correlation coefficients. Coefficients of determination (r^2) were also calculated to show the percentage of plant height variation determined by seedling length before transplanting.

The possibilities of selecting short plants based on the seedling length in the nursery were investigated in the first and second crops of 1969. The experimental materials consisted of three F_2 populations each from an intra-japonica, an indica- japonica, and an intra-indica crosses. For intra-japonica crosses, C 223 x Pi No. 4 was used in the first crop and Line 54233 x Nohrin 22, in the second one, whereas indica-japonica cross, Chianung 242 x IR 9-60, and intra-indica, cross Taichung native 1 x Century Patna 232 (CP 231) were used in both crops. C 223, Line 54233, Chianung 242, and CP 231 were used as tall parents whereas Pi No. 4, Nohrin 22, IR 9-60, and Taichungnative 1, as short ones. F_2 as tall and parental seedlings were grown in the ordinary wet nursery. On the day of transplanting, F_2 seedlings were visually classified into tall, intermediate, and short groups with unselected seedlings used as the control .These four groups of F_2 seedlings together with both parents were arranged in a randomized block design experiment with 3 replications. Individual plots consisted of four rows with 4 m in length. The plant spacing was 25 x 20 cm with one seedling per hill. Standard cultural practices were followed for the management of the experimental plots.

After transplanting, 60 plants were selected at random to represent each group of F_2 and parents and data for plant height, heading date, number of panicles, and grain yield were obtained from each plant. Plant height was measured once every 30 days up to the full maturity of rice plant. Genetic variances were also calculated to compare the efficiency of visual selection of plant height based on the seedling length brfore transplanting. Heritability in broad sense was determined for seedling length and plant height at various growing stages based on data obtained from unselected F_2 populations. F_2 variance method used by Mahmud and Kramer (1951) was followed in the calculation of heritability values.

EXPERIMENTAL RESULTS

Relationship Between Seedling Length and Plant Height in Rice Varieties.

Correlation coefficients between seedling length and plant height at vario us growing stages are presented in Table 1. Seedling length measured just before transplanting was

found to be highly correlated with plant height during the early stages of growth in both crops. However, the magnitude of correlations gradually decreased with the progress of rice development. When rice plants were fully matured (about 120 and 90 days after transplanting in the first and the second crops, respectively), the correlation coefficient between seedling length and plant height in the first crop failed to reach a singificant level whereas in the second one it remained to be significant at the 1% level, although the magnitude of correlation was rather small. Coefficients of determination (r^2) revealed that more than 30% of plant height variation in both crops could be ascribed to the effect of seedling length before transplanting. However, its influence declined rapidly and at heading stage (about 90 and 60 days in the first and second crops, respectively), seedling length was able to determine only 12% of the variation in plant height. The coefficients of determination reduced to about 3 and 11% in the first and the second crops respectively when rice plants reached the final stage of growth.

Table 1. Correlation coefficents and coefficients of determination between seedling length before transplanting and plant height at various growing stages in randomly selected varieties of rice.

Crop season	Coefficent	Days after transplanting				Degree of freedom
		30	60	90	120	
First crop, 1969	Correlation (r)	0.5477**	0.4101**	0.3547**	0.1656	93
	Determination (r^2)	0.3000	0.1682	0.1258	0.0274	
Second crop, 1969	Correlation (r)	0.5870**	0.3521**	0.3335**	—	92
	Determination (r^2)	0.3446	0.1240	0.1112	—	

** Significant at the 1% level.

Influence of Seedling Length on Plant Height.

The average seedling length measured on the day of transplanting and the mean plant height recorded at different stages of growth for both parents and four groups of F_2 populations in the first and the second crops are given in Table 2 and 3, respectively. In the first crop, seedlings of tall parents were generally taller than those of short parents, and the same situation also prevailed in plant height. In the second crop, however, short parents were found to produce tall seedlings and vice versa. Nevertheless, seedlings of tall parents were capable of more rapid growth and the superiority of tall parents in plant height over short parent was apparent at the time of tillering stage (30 days after transplanting). Rice plants of both parents differed very slightly in plant height at tillering stage and substantial difference in plant height between tall and short parents was not evident until 60 days after transplanting in both crops.

Table 2. Mean seedling length before transplanting and plant height at different growth stages for both parental and F_2 populations in the first crop of 1969.

Cross combination	Population*	Seedling length (cm)		Plant height (cm)							
		At trans-planting	Rank	30** DAT	Rank	60 DAT	Rank	90 DAT	Rank	120 DAT	Rank
C 223 x Pi No. 4	P_1	35.0	1	35.3	1	73.3	1	114.3	1	144.5	1
	P_2	25.5	3	25.6	6	42.0	6	85.9	6	90.7	6
	F_2 CK	24.9	5	31.5	3	52.8	3	100.7	3	103.5	4
	F_2 T	29.9	2	32.8	2	53.9	2	102.8	2	106.6	2
	F_2 M	25.2	4	29.4	4	51.9	4	99.2	4	104.3	3
	F_2 S	19.7	6	25.9	5	49.6	5	94.3	5	102.4	5
Chianung 242 x IR 9-60	P_1	19.9	2	29.6	2	66.8	1	110.3	2	130.3	1
	P_2	15.8	5	26.0	5	55.3	6	70.9	6	86.7	6
	F_2 CK	18.6	4	27.7	3	64.2	3	102.8	4	125.3	3
	F_2 T	22.6	1	33.1	1	66.1	2	111.6	1	126.6	2
	F_2 M	18.7	3	17.0	4	63.8	4	103.2	3	123.6	4
	F_2 S	13.5	6	22.1	6	57.4	5	90.8	5	114.6	5
Tacihung native 1 x CP 231	P_1	14.2	5	27.1	5	59.8	6	82.3	6	95.7	6
	P_2	21.6	2	30.1	2	74.4	1	120.8	1	142.6	1
	F_2 CK	17.4	4	29.0	3	67.4	4	98.6	4	123.3	4
	F_2 T	22.2	1	31.2	1	70.5	2	113.4	2	137.8	2
	F_2 M	18.2	3	27.6	4	69.0	3	105.2	3	130.3	3
	F_2 S	13.6	6	24.6	6	61.7	5	88.6	5	114.9	5

* P_1, P_2=Parental Varieties. F_2 CK, T, M, S =F_2 populations of unselected, selected for tall, intermediate, and short seedlings, respectively.

** DAT=Days after transplanting.

Table 3. Mean seedling length before transplanting and plant heigh at different growth stages for both parental and F_2 populations in the second crop of 1969.

Cross combination	Population*	Seedling length (cm)		Plant height (cm)					
		At trans-planting	Rank	30** DAT	Rank	60 DAT	Rank	90 DAT	Rank
Line 54233 x Nohrin 22	P_1	17.4	3	61.3	1	95.3	1	96.3	1
	P_2	16.7	5	54.3	5	87.2	4	87.2	5
	F_2 CK	18.0	2	55.9	3	84.9	5	87.6	3
	F_2 T	21.2	1	59.5	2	89.6	2	89.9	2
	F_2 M	16.7	4	55.1	4	87.3	3	87.3	4
	F_2 S	12.9	6	50.3	6	83.8	6	83.9	6
Chianung 242 x IR 9-60	P_1	17.2	5	53.6	2	106.3	1	107.0	1
	P_2	19.7	2	52.0	4	75.2	6	79.6	6
	F_2 CK	17.6	4	49.5	5	88.7	4	99.8	5
	F_2 T	24.1	1	58.3	1	96.8	2	103.7	3
	F_2 M	18.8	3	52.8	3	94.0	3	104.0	2
	F_2 S	14.7	6	46.8	6	85.6	5	100.4	4
Taichung native 1 x CP 231	P_1	20.0	4	52.4	5	74.9	5	80.8	6
	P_2	18.6	5	58.3	2	99.6	1	113.8	1
	F_2 CK	20.9	3	52.6	4	78.6	4	95.2	4
	F_2 T	26.8	1	59.7	1	91.6	2	105.3	2
	F_2 M	21.6	2	54.2	3	82.1	3	98.7	3
	F_2 S	17.6	6	49.4	6	74.8	6	92.2	5

* P_1,P_2=Parental varieties. F_2 CK, T, M, S=F_2 populations of unselected, selected for tall, intermediate, and short seedlings, respectively.

** DAT=Days after transplanting.

For F_2 seedlings, visual selection before transplanting resulted in three distinct groups with different seedling length in both crops. The difference among the mean seedling length of selected F_2 populations was highly significant for each cross in both crops (Table 4), and this difference in seedling length was maintained throughout the whole stages of growth. As a result, selected tall seedlings generally produced tall plants whereas rice plants from seedlings selected for shortness were found to be usually associated with short plant height at different growing stages. The difference in mean plant height at maturing stage was significant at 1% level in four populations of F_2 and among three selected F_2 populations except the cross of Chianung 242 x IR 9-60 in the second crop.

Average plant height of intermediate seedlings generally ranked between that of tall and short seedlings. The influence of seedling length on plant height differed slightly among crosses of rice.

Table 4. Mean squares of seedling length before transplanting and plant height at maturing stage in F_2 populations of rice crosses.

Crop season	Cross combination	Source of variation	Degree of freedom	Mean squares	
				seedling length	Plant height
First crop, 1969	C 223 x Pi No.4	F_2 populations	3	1,759.15**	219.47**
		Selected vs. unselected	1	0.02	50.96
		Among selected	2	2,638.71**	303.72**
	Chianung 242 x IR 9-60	F_2 populations	3	1,393.46**	1,526.47**
		Selected vs. unselected	1	10.32	504.95
		Among selected	2	2,085.03**	2,037.23**
	Taichung native 1 x CP 231	F_2 populations	3	1,264.18**	5,745.53**
		Selected vs. unselected	1	23.35*	861.11
		Among selected	2	1,884.59**	8,187.75**
Second crop, 1969	Line 54233 x Nohrin 22	F_2 populations	3	1,191.83**	323.52**
		Selected vs. unselected	1	81.18**	5.52
		Among selected	2	1,747.16**	482.52**
	Chianung 242 x IR 9-60	F_2 populations	3	1,558.36**	263.41**
		Selected vs. unselected	1	211.68**	309.97
		Among selected	2	2,231.70**	240.22
	Taichung native 1 x Cp 231	F_2 populations	3	1,429.89**	1,814.27**
		Selected vs. unselected	1	91.63**	602.27
		Among selected	2	2,099.02**	2,420.28**

* Significant at 5% level.

** Significant at 1% leval.

Genetic Variance of Plant Height.

Genetic variances of plant height measured at maturing stage in four F_2 populations are shown in Table 5. It was observed that genetic variances of F_2 populations from visually selected seedlings were generally smaller than those of the F_2 populations from unselected seedlings in the first crop, except the plant height from short seedlings in the cross of Chianung 242 x IR 9-60. The results obtained in the second crop were just the opposite to those of the first crop, except that from intermediate seedlings in the cross of Line 54233 x Nohrin 22. Among selected F_2 populations, genetic variances from tall seedlings were the smallest, followed by intermediate seedlings whereas those from short seedlings, the largest in the first crop, except in the cross of intra-japonica cross, C 223 x Pi No. 4 where genetic variance from intermediate seedlings was the smallest. In the second crop however, populations from intermediate seedlings showed the smallest genetic variance, followed by tall seedlings and, as in the first crop, those from short seedlings gave the largest genetic variances in 3 crosses of rice. Genetic variances for plant height were considerably lower in intra-japonica crosses in comparison with those of indica-japonica and intra-indica crosses. Differences in genetic variances of plant heignt between crop seasons was not evident

Table 5. Genetic variances of plant height at maturing stage in F_2 populations of 3 rice crosses.

First crop, 1969			Second crop, 1969		
Cross combination	F_2 populations*	Genetic variance	Cross combination	F_2 population*	Genetic variance
C 223 x Ni No. 4	F_2 CK	27.31	Line 54233 x Nohrin 22	F_2 CK	28.90
	F_2 T	16.49		F_2 T	40.82
	F_2 M	0		F_2 M	9.05
	F_2 S	23.33		F_2 S	42.81
Chianung 242 x 9-60	F_2C K	160.91	Chianung 242 x IR 9-60	F_2 CK	121.67
	F_2 T	78.11		F_2 T	149.23
	F_2 M	113.79		F_2 M	126.11
	F_2 S	251.72		F_2 S	151.10
Taichung native 1 x CP 231	F_2 CK	240.42	Taichung native 1x CP 231	F_2 CK	133.58
	F_2 T	156.73		F_2 T	193.30
	F_2 M	179.40		F_2 M	176.94
	F_2 S	194.94		F_2 S	241.12

* F_2 CK, T, M, S=F_2 populations from unselected, selected for tall, intermediate, and short seedlings, respectivly.

Estimates of Heritability.

Heritability estimates for seedling length and plant height at different stages of growth are given in Table 6. Heritability values of seedling length at the time of transplanting were generally low in all crosses. However, the inter-type cross, Chianung 242 x IR 9-60 gave relatively large values of heritability in both crops when compared with those of intra-type crosses of india or japonica rice varieties. The intra-japonica cross, C 223 x Pi No. 4 and the intra-indica, cross Taichung native 1 x CP 231 gave negative values of heritability for seedling length in the first and the second crops respectively, and they were replaced with zeroes.

After the transplanting of rice seedlings, heritability estimates gradually increased and when rice plants were fully matured, heritability values of plant height were considerably greater than those of seedling length in all crosses. As in the case of seedling length, heritability estimates for plant height were larger in the indica-japonica cross, Chianung 242 x IR 9-60 in both crops than either intra-japonica or intra-indica crosses. Intra-japonica cross of rice gave the lowest values of heritability for plant height at maturing stage. Heritability values differed only slightly with crop seasons for both seedling length and plant height in all crosses of rice.

Table 6. Heritability estimates for seedling length and plant height at different stages of growth in unselected F_2 populations of rice crosses.

Crop season	Cross	Heritability (%)				
		0 DAT*	30 DAT	60 DAT	90 DAT	120 DAT
First crop, 1969	C 223 x Pi No. 4	0	0	2.82	42.58	51.68
	Chianung 242 x IR 9-60	40.41	43.60	65.21	84.23	90.34
	Taichung native 1 x CP 231	15.69	16.10	29.30	66.67	88.93
Second crop, 1969	Line 54233 x Nohrin 22	34.74	45.54	58.50	54.44	—
	Chianung 242 x IR 9-60	30.46	31.71	48.57	87.76	—
	Taichung native 1 x CP 231	0	42.10	70.14	84.06	—

* DAT=Days after transplanting. 0 DAT=The day of transplanting.

DISCUSSION

It was observed that correlation coefficients between seedling length and plant height decreased gradually with the progress of rice growth, showing that considerable changes in plant height had taken place after the transplanting of rice seedlings into the paddy field. Since the development of rice plants is a dynamic process, many changes are likely to occur from young seedlings stage to the fully matured plants. Although correlation coefficients between seedling length before transplanting and plant height at maturing stage were rather small in their magnitude, especially in the first crop, there was still evidence to indicate a possible association of plant height of fully matured rice plants in the paddy field with seedling length in the nursery bed. It seems probably that seedling length may be under the influence of the same genetic factors controlling plant height. The relatively small magnitude of correlations between these two traits in this experiment may be caused by the difference in the mode of inheritance among rice varieties, since the genetic control of plant height was reported to vary from relatively simple monogenic inheritance (Chang et al., 1965 ; Aquino and Jennings, 1966) to rather complicated polygenic one (IRRI, 1967 ; Syakudo et al., 1957) 。Furthermore, rice varieties sampled for the calculation of correlation coefficient in this experiment may also not be sufficient to cover necessary varietal types as well as levels of plant height for an adequate manifestation of the relationship.

The effect of selection for plant height in the nursery before transplanting instead of carrying out in the paddy field at maturing stage in F_2 populations was evaluated by the comparison of mean plant weight and genetic variance. It was observed that rice plants derived from the tall, intermediate, and short seedlings were also associated with tall, intermediate, and short stature at maturing stage, the difference in mean plant height being highly significant in most cases. The consistency in the order of seedling length at transplanting and plant height at maturity clearly demonstrated that visual classification of rice seedlings into groups of different length was effective in differentiating fully d eveloped rice plants into groups with distinct plant height. It appears feasible, therefore, that selection for plant height in F_2 populations can be made before transplanting based on the length of individual seedlings.

If visual classification of rice seedlings into groups of different length was effective in increasing the frequency of genotypes with potentially similar plant height, a reduction in genetic variance would be expected within each selected population. It was found that genetic variances of plant height at maturing stage for unselected F_2 populations were generally larger than each selected F_2 population in the first crop, indicating that selection for plant height through seedling length was effective. In the second crop, however, genetic variances associated with unselected F_2 populations were considerably smaller than those associated wih selected F_2 populations especially those of indica-japonica and intra-indica crosses, showing that visual salection of seedling length was less effective under the conditions prevailing in the second crop. Among selected F_2 populations, genetic variances of plant height were considerably larger in the populations of short seedlings when com-

pared with those of either intermediate or tall seedlings for all crosses in both crops, showing that short seedlings selected in the nursery are less likely to develop rice plants with short stature whereas rice seedlings identified as either intermediate or tall are more likely to produce rice plants with relatively tall plant height. It appears likely that the efficiency of selection for short stature rice plants can be greatly improved by simply discarding the obviously taller seedlings in the nursery instead of selecting short seedlings for the transplanting.

It was found that short parents of indica varieties, Taichung native 1 and IR 9-60 produced taller seedlings than their respective tall parents in the second crop, indicating that the growth of rice seedlings produced by the short indica varieties can be greatly stimulated by the high temperature prevailing during the nursry stage. Aquino and Jennings (1966) also suggested that the dwarf gene for plant height seems to have the pleiotropic effect of strong seedling vigor. Thus, F_2 rice seedlings with dwarf gene may have better growth and phenotypically similar to seedlings with tall gene, resulting in the misclassification of the rice seedlings. This may partly explain why the selected F_2 populations were always associatd with larger genetic variances of plant height at maturing stage in the second crop.

The growth of rice seedlings may also be affected by other factors. For example, the large seeds with large endosperm usually give better growth of seedlings (Matsubayashi, 1963). Therefore, seedling length of large-sized seeds may grow considerably taller than those of small-sized seeds, even though they may have the same genetic constitution for plant height. In this experiment, the nursery bed was established in the field and sowing was made by the ordinary method. Therefore. seeds in the sparsely spaced area may germinate earlier and grow better when compared with those in the more densely spaced area. It appears likely that part of rice seedlings classified as short may not be really with dwarf gene but are short because of poor growth under the nursery conditions. When transplanted into paddy field, these poor growing short seedlings will quickly recover to the normal growth. These factors, together with others mentioned earlier, may have contributed to the large genetic variance of plant height for F_2 populations derived from short seedlings.

For visual selection to be effective, the heritability percentage of the attribute being selected must be substantially high. The heritability estimates obtained for plant height at maturing stage were generally high especially in the crosses between indica-japonica and intra-indica varieties. The high estimates of heritability obtained in this experiment were not surprising as quite high heritability values have previously been reported by other workers (Oung and Chang, 1958 ; Toriyama and Futsuhara, 1958 ; Nei, 1960). Although heritability percentages for seedling length in the nursery were rather erratic, the values of 30% or larger obtained for certain crosses in this experiment may be considered high enough for visual selection to be successful. The estimated heritability value of 30.46% for seedling length in the indica-japonica cross, Chianung 242 x IR 9-60 was actually comparable to the value of 31.7% reported for plant height in an indica x japonica cross (Oka, 1956). However, the practical value of heritability for seedling length may subject to the influence

of both internal and external factors under the growing conditions during the nursery stage.

SUMMARY

A total of 95 and 94 varieties of rice were randomly selected in the first and the second crops of 1969 respectively for the calculation of correlation coefficients between seedling length and plant height. Most correlations reached the significant level, although the magnitude of the correlations decreased with the development of rice plants.

Rice seedlings of three F_2 populations were visually classified into tall, intermediate, and short groups before transplanting to find out whether rice seedlings of different seedling length would result in matured plant with different plant height. It was found that tall seedlings generally produced tall plants whereas short plants developed from short seedlings. The differences in mean seedling length as well as mean plant height were highly significant among selected populations. Genetic variances of plant height at maturing stage for selected F_2 populations were considerably smaller than those of unselected F_2 populations for all crosses in the first crop, whereas in the second crop, the reverse was generally true. Heritability percentages estimated for seedling length ranged from nil to 40.4%, varying with crosses and crops.

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水稻苗高與株高之相關及其對選拔短稈植株之影響

張　萬　來

民國58年第1期作與第2期作分別選出95及94個水稻品種計算苗高與株高間之相關係數。就所得結果可知插秧前苗高與種植後各生育時期之株高成極顯著之正相關，惟其相關係數隨水稻之生長而逐漸遞減。

插秧前將水稻F_2集團秧苗以目測方法依其長度區分爲高、中、短三羣另以不加選拔者爲對照觀察其移植後之稻株高度及其變異。初步結果顯示高苗常導致高株而短苗則多矮株。不同苗高羣間之苗高與株高差異多達極顯著水準。經過選拔之各羣，其第1期作成熟期株高遺傳變方較對照者爲小，惟在第2期作則較對照者爲大，F_2 集團苗高之遺傳力分佈在0與40.4%之間，其大小因組合及期作而異。

水稻氮肥施肥技術之研究（第一報）
氮肥晚期施用對水稻產量及養分吸收之影響

邱再發　　黃文良

一、前　　言

近來本省稻谷產量年有增加，1968年已有252萬公噸之糙米生產；同時糧食局所配銷之化學肥料亦逐年增加，1968年有86萬公噸，其中稻作肥料之氮素含量佔三要素中之72%，而稻作肥料則佔全部化學肥料總量之79%，即71萬公噸，且臺灣農家之施肥量尚在繼續增加之中（1）。

一般水稻產量愈多者，其無機養份吸收量也愈多，為使稻谷產量增加，需要供給更多的養分，以利水稻吸收；但多量肥料之施用，不一定可達到增產之目的，如何使多量肥料完全被水稻吸收利用係值得研究之施肥技術之一，尤其過去本省之水稻肥料試驗結果，均顯示氮肥之施用方法，影響稻產量最甚。

最近氮素肥料之施肥技術，似注重於氮肥之分施及施用時期。追肥之實施可供給水稻生育途中各時期所需要之氮素，但追肥之時期及用量若不適當時，亦可引起病蟲害及減產之危險。為確立理想之氮素肥料施用技術，現在習用之施肥方法有研討之必要，且須瞭解各種環境，條件及水稻營養情況。筆者為明瞭稻谷產量，水稻品種之三要素吸收量，氮肥種類，施肥時期及用量等關係，1968年於羅東、樹林、桃園三處舉行水稻田間肥料試驗。本研究之目的為在各種土壤之不同氮肥施用方法下，探求水稻氮素營養與產量之關係，而闡明氮肥之晚期施用效果，俾資農家施肥之參考。

本研究蒙國家科學委員會及農復會之補助、並得農業試驗所植物營養研究室同仁協助完成試驗，本文復蒙農復會蘇楠榮博士斧正，謹此一併致謝。

二、試驗方法

使用兩種品種，蓬萊種新竹56及在來種矮脚尖。民國57年在三處不同水田土壤即（1）羅東粘板岩冲積土，（2）樹林砂岩頁岩冲積土，（3）桃園紅壤進行田間試驗。田間設計為七種肥料處理，五重複共三十五小區，小區面積 1/1000 公頃，各品種皆有三十五小區，隨機區集排列，每小區栽植250欉，栽植行距 25cm×16cm，肥料處理注重水稻生育中期之氮缺乏，配合生育晚期之氮素追肥效果，以期獲致稻谷高產量。另使用臺製之化成肥料（尿素系）16—8—12 及日製化成肥料（磷銨系）15—15—10，以硫銨為對照探究其肥效，處理內容如表1。

表1.　田間試驗肥料處理

Table 1. Fertilizer treatments of the field experiment

處理區名 Plot name	三要素量 kg/ha N—P_2O_5—K_2O	各時期氮素用量 Nkg/ha Amount of N applied at different stages (插秧後日數 Days after transplanting)						
		0	15	25	65	75	85	95 (第一期作) 1st crop
		0	8	18	50	58	65	72 (第二期作) 2nd crop
1 硫安N 100 對照區 Amm. Sulf. Control	100—60—60	50	25	25	—	—	—	—
2 硫安 N100 晚施區 Amm. Sulf. Late appli.	100—60—60	30	30	—	20	10	5	5

3 硫安 N120 晚施區 Amm. Sulf. Late appli.	120—60—60	36	36	—	24	12	6	6
4 硫安 N140 晚施區 Amm. Sulf. Late appli.	140—60—60	42	42	—	28	14	7	7
5 尿素 N140 晚施區 Urea Late appli.	140—60—60	42	42	—	28	14	7	7
6 日製化成肥料區 Japan compound fertilizer	100—100—60	50	25	25	—	—	—	—
7 台製化成肥料區 Taiwan compound fertilizer	100—50—75	50	25	25	—	—	—	—

各時期採取水稻樣本，以農試所植物營養研究室經常分析之迅速測定法（2），定量樣本中之氮、磷、鉀含量。另採取試驗地水田土壤，定量其全氮含量外，將濕土以 N—KCl溶液振搖，抽取上澄液，應用擴散法（3），定量土壤之銨態氮及硝酸態氮。

三、結果與討論

I 田間試驗結果

本試驗之氮肥晚期施用處理，對稻谷產量有顯著的增產效果。兩品種×兩期作×三處試驗地，即共十二個肥料試驗之中，稻谷產量處理差異達1％顯著標準者有九個，僅有三個試驗，稻谷有增產，但未達到顯著標準（表2及3）。

本試驗所使用之矮脚尖及新竹56號均爲本省北部產量較高之品種。此兩品種對氮肥處理都表現同樣的效應，即對多氮晚期施用處理，尤其第四處理(N140 晚施)有顯著的增產。第一期作新竹56號對氮肥的效應，比矮脚尖爲大，即前者比對照區增產12％，後者6％，但在第二期作新竹 56 號增產6％，稻谷藁矮脚尖增產11％。矮脚尖第一期作之稻谷平均產量比新竹56號爲高，但在第二期作新竹56號反而比矮脚尖爲高。稻谷產量之兩期作總平均結果兩品種間差異甚微，即矮脚尖稻谷平均產量爲4.93公噸/公頃，新竹56號爲5.00公噸/公頃。

表2. 肥料處理對水稻產量之影響；第一期作試驗 (公噸/公頃)

Table 2. The effect of the fertilizer treatment on the yields of rice, the lst crop 1968 (ton/ha)

品種 Variety	處理 Treatment	羅東 Lotung		桃園 Taoyuan		樹林 Shulin		平均 Mean	
		谷（指數）Grain (Index)	藁（指數）Straw (Index)	谷 Grain	藁 Straw	谷 Grain	藁 Straw	谷 Grain	藁 straw
矮脚尖 Aichiawchien	1.N100對照	4.94(100)	3.36(100)	4.59(100)	5.00(100)	5.78(100)	4.52(100)	5.10(100)	4.29(100)
	2.N100晚施	4.84(98)	3.24(96)	4.41(96)	5.01(100)	6.00(104)	4.66(103)	5.08(100)	4.30(100)
	3.N120晚施	4.98(101)	3.38(101)	4.55(99)	4.57(91)	6.32(109)	5.15(114)	5.28(104)	4.37(102)
	4.N140晚施	5.18(105)	3.60(107)	4.56(99)	5.21(104)	6.43(111)	4.95(110)	5.39(106)	4.59(107)
	5.N140（尿素）晚施	5.24(106)	3.60(107)	4.74(103)	4.23(85)	6.02(104)	5.29(117)	5.33(105)	4.37(102)
	6.日化成肥	4.92(100)	3.44(102)	4.68(102)	4.99(100)	5.92(102)	4.82(107)	5.17(101)	4.42(103)
	7.臺化成肥	4.36(88)	3.08(92)	4.28(93)	4.94(99)	5.60(97)	4.59(102)	4.75(93)	4.20(98)
	F 值	5.83**	3.12*	2.02 N.S	1.66 N.S.	8.37**	1.19 N.S.		

新竹五六 Hsinchu 56	1.N100對照	4.62(100)	3.00(100)	3.99(100)	4.77(100)	5.90(100)	4,74(100)	4.84(100)	4.17(100)
	2.N100晚施	4.50(97)	2.60(87)	4.59(115)	5.06(106)	6.43(109)	4.85(102)	5.17(107)	4.17(100)
	3.N120晚施	4.84(108)	2.90(97)	4.38(110)	4.84(101)	6.31(107)	5.06(107)	5.18(107)	4.27(102)
	4.N140晚施	5.22(113)	3.24(108)	4.54(114)	4.61(97)	6.57(111)	5.67(120)	5.44(112)	4.51(108)
	5.N140 (尿素) 晚施	5.06(110)	3.28(109)	4.41(111)	4.65(97)	6.49(110)	5.36(113)	5.32(110)	4.43(106)
	6.日化成肥	4.62(100)	2.98(99)	4.14(104)	4.37(92)	5.77(98)	4.90(103)	4.84(100)	4.08(98)
	7.臺化成肥	4.04(87)	2.48(88)	3.85(97)	4.81(101)	5.78(98)	4.35(92)	4.56(94)	3.88(93)
	F 值	12.91**	11.21**	4.35**	N.S.	13.07**	4.36**		

註：理論 F值 (Theoretical F-value) 爲 5 %2.51,1%3.67

表3. 肥料處理對水稻產量之影響；第二期作試驗 (公噸/公頃)

Table 3. The effect of the fertilizer treatment on the yields of rice, the 2nd crop 1968 (ton/ha)

品種 Variety	處理 Treatment	羅東 Lotung		桃園 Taoyuan		樹林 Shulin		平均 Mean	
		谷 (指數) Grain	藁 (指數) Straw	谷 Grain	藁 Straw	谷 Grain	藁 Straw	谷 Grain	藁 Straw
矮脚尖 Aichiawchien	1.N100對照	4.54(100)	4.64(100)	4.87(100)	5.78(100)	3.78(100)	4.23(100)	4.40(100)	4.88(100)
	2.N100晚施	4.88(107)	4.20(91)	5.21(107)	5.63(97)	4.34(114)	5.03(119)	4.81(109)	4.95(101)
	3.N120晚施	4.98(110)	4.64(100)	5.19(107)	5.82(101)	4.27(112)	4.82(114)	4.81(109)	5.09(104)
	4.N140晚施	5.18(114)	5.00(108)	5.27(108)	5.81(100)	4.23(111)	4.98(118)	4.89(111)	5.26(108)
	5.N140 (尿素) 晚施	5.06(111)	4.66(100)	5.25(108)	5.48(95)	4.29(113)	4.65(110)	4.86(110)	4.93(101)
	6.日化成肥	4.80(106)	4.80(103)	5.09(105)	6.02(104)	3.86(102)	4.51(107)	4.58(104)	5.11(105)
	7.臺化成肥	4.66(103)	4.48(97)	4.90(101)	5.67(98)	4.01(105)	4.31(102)	4.52(103)	4.82(99)
	F 值	3.96**	2.56N.S.	N.S.	N.S.	4.00**	3.09*		
新竹五六 Hsinchu 56	1.N100對照	5.14(100)	3.98(100)	5.66(100)	6.16(100)	3.83(100)	5.02(100)	4.88(100)	5.05(100)
	2.N100晚施	4.84(94)	3.82(96)	5.92(105)	5.47(93)	4.02(105)	4.32(86)	4.93(101)	4.63(92)
	3.N120晚施	5.06(98)	3.90(98)	6.06(107)	6.18(100)	3.97(104)	4.92(98)	5.03(103)	5.00(99)
	4.N140晚施	5.36(104)	4.26(107)	6.06(107)	6.08(99)	4.02(105)	4.86(97)	5.15(106)	5.07(100)
	5.N140 (尿素) 晚施	4.88(95)	3.80(96)	5.94(104)	5.80(94)	3.90(102)	4.84(96)	4.91(101)	4.81(95)
	6.日化成肥	5.14(100)	3.72(93)	5.56(98)	6.32(103)	3.98(104)	4.98(99)	4.89(100)	5.01(99)
	7.臺化成肥	4.66(91)	3.78(95)	5.84(103)	6.56(106)	3.88(101)	4.96(98)	4.79(98)	5.10(101)
	F 值	4.10**	1.65N.S.	3.58**	1.85N.S.	N.S.	1.89N.S.		

註：理論 F 值 (Theoretical F-value) 爲 5 %2.51，1%3.67 。

由生育調查結果（表4及5）可以看出，有增產之處理區水稻之穗數並無顯明的增加，所以此增產之直接要素是穗重的增加。本試驗之處理重點爲氮肥之晚期施用。基肥及早期追肥僅促進適當的分蘗數即獲得適當的穗數爲目的，而全部氮肥之40%做爲晚期施用，即出穗前約20天至成熟期，收獲前20天，即在生殖生長期中，分四次施用。此晚期施肥之主要目的爲增加穗重，期待對一穗粒數千粒重或稔實率等產量構成要素有良好效果而引起穗重之增加。

由株高調查結果可知氮肥多量施用很明顯的促進蓬萊種水稻之株高，同時有稻谷增產之效果。對矮性在來種，矮脚尖之株高並無影響。水稻收獲時株高之外，另調查劍葉（最後伸長出來之葉片，即穗下面之第一葉）之長度。關於株高及劍葉長對稻谷產量之相關如何？由新竹56號水稻統計分析，結果表示，本驗試之水稻株高與稻谷產量之相關係數爲 $r=0.78$ ，但劍葉長與稻谷產量之相關更大，$r=0.87$ 。產量與株高或產量與劍葉之相關規則在一般水稻田也許不能適用，但如本試驗在同一環境下之水田若應用合理的氮肥施用技術可增加劍葉長或株高者，似可增加稻谷產量。地點不同時水稻株高相差很大。對同一品種而言，樹林之株高比桃園及羅東兩處較高。

表4. 第一期作試驗收獲時之水稻株高又每欉穗數

Table 4. The number of panicles per hill and the height of rice in the lst crop experiment.

品種 Variety	處理 Treatment	羅東 Lotung 株高 Height cm	羅東 Lotung 穗數 No. of panicles	桃園 Taoyuan 株高 Heigh cm	桃園 Taoyuan 穗數 No. of panicles	樹林 Shulin 株高 Height cm	樹林 Shulin 穗數 No. of panicles	平均 Mean 株高 Height cm	平均 Mean 穗數 No. of panicles
矮脚尖 Aichiawchien	1.N100對照	86.4	11.1	83.2	12.0	89.2	11.8	86.3	11.6
	2.N100晚施	84.4	11·1	79.4	11.8	92.8	13.3	85.5	12.1
	3.N120晚施	85.2	10.9	79.6	11.0	89.6	12.8	84.8	11.6
	4.N140晚施	87.2	12.4	79.2	10.5	90.6	14.0	85.7	12.3
	5.N140（尿素）晚施	86.2	11 5	82.8	10.6	92.0	16.2	87.0	12.8
	6.日化成肥	86.8	11.9	87.0	11.0	88.8	11.4	87.5	11.4
	7.臺化成肥	85.8	10.1	81.2	11.8	88.4	11.8	85.1	10.8
	平均Mean	86.0	11.3	81.7	11.2	90.2	13.0	86.0	11.8
新竹五六 Hsinchu 56	1.N100對照	105	9.9	96.6	12.8	103	15.3	101.5	12.7
	2.N100晚施	101	7.0	95.0	11.2	109	14.4	101.7	10.9
	3.N120晚施	104	11.1	97.4	10.4	112	15.6	104.5	12.4
	4.N140晚施	106	11.1	95.0	11.2	113	17.1	104.7	13.1
	5.N140（尿素）晚施	109	10.7	98.0	12.3	107	13.7	104.7	12.2
	6.日化成肥	104	10.6	97.8	12.3	105	13.0	105.8	12.0
	7.臺化成肥	108	9.7	95.0	11.3	102	12.8	101.7	11.3
	平均Mean	105.3	10.0	96.4	11.5	107.3	14.6	103.0	12.0

表5. 第二期作試驗收穫時之水稻株高及每欉穗數

Table 5. The number of panicles per hill and the height of rice in the 2nd crop experiment

品種 Variety	處理 Treatment	羅東 Lotung 株高 Height cm	羅東 Lotung 穗數 No.of panicles	桃園 Taoyuan 株高 Height cm	桃園 Taoyuan 穗數 No.of panicles	樹林 Shulin 株高 Height cm	樹林 Shulin 穗數 No.of panicles	平均 Mean 株高 Height cm	平均 Mean 穗數 No.of panicles
矮腳尖 Aichiawchen	1.N100對照	84.9	12.9	88.1	16.2	90.3	15.4	87.8	14.8
	2.N100晚施	81.2	12.7	86.0	13.7	87.9	16.4	85.0	14.3
	3.N120晚施	84.2	11.4	85.8	12.5	89.1	16.2	86.4	13.4
	4.N140晚施	83.9	13.3	86.3	13.3	90.8	17.1	87.0	14.6
	5.N160（尿素）晚施	82.4	11.4	85.9	14.6	89.8	16.0	86.0	14.0
	6.日化成肥	84.2	11.8	89.0	15.0	89.1	16.3	87.7	14.4
	7.臺化成肥	84.3	11.0	89.5	14.0	89.4	14.9	87.7	13.3
	平均Mean	83.6	12.1	87.2	14.1	89.5	16.0	86.8	14.1
新竹六五 Hsinchu 56	1.N100對照	97.2	11.9	108.9	14.0	115.3	12.4	107.1	12.8
	2.N100晚施	94.7	9.7	103.9	13.2	110.9	12.7	103.2	11.9
	3.N120晚施	96.1	10.3	106.3	12.2	111.4	13.3	104.6	11.9
	4.N140晚施	100.1	12.2	106.4	14.6	112.1	11.9	106.2	12.9
	5.N140（尿素）晚施	95.6	10.0	104.9	11.0	114.1	11.1	104.9	10.8
	6.日化成肥	95.2	11.0	108.2	12.0	115.2	12.5	106.2	11.8
	7.臺化成肥	95.5	10.0	106.9	15.6	111.8	13.0	104.7	12.9
	平均Mean	96.3	10.8	106.5	13.2	113.0	12.4	105.3	12.1

關於兩期作之水稻產量比較，稻谷產量第一期作比第二期作爲高，但藁產量第二期作比第一期作爲高，與本省一般水稻產量情況相同。第一期作產量總平均爲谷 5.11 公噸/公頃，藁4.29公噸/公頃，稻/藁比率爲119/100。第二期作之產量總平均爲谷 4.82 公噸/公頃，藁 4.98公噸/公頃，谷/藁比率爲97/100。出穗期第一期作爲插秧後79天至82天，第二期作爲60天至 64 天（表 6 ）。本試驗之晚期施肥日期爲第一期作65天至95天第二期作50天至72天，剛在出穗期前後，都有多量氮肥之施用。雖然兩品種在各地出穗期不一致而全部氮肥之40%分施在此期間，但試驗結果表示，此種施肥方法，不但無減產危險，而各地均有增產效果。

表6. 水稻之出穗和收穫日期及其插秧後日數

Table 6. The date of heading and harvesting of rice and their number of days after transplanting

	調查項目 Items investigated		羅東 Lotung	桃園 Taoyuan	樹林 Shu lin	平均 Mean
第一期作 1st criop	插秧 (月：日) Trans planting (month:day)		Ⅲ：27	Ⅳ：7	Ⅲ：21	
	出穗期 Date of heading	矮脚尖 Aichiaw-chien	Ⅵ：14(79天)	Ⅵ：21(75天)	Ⅵ：12(83天)	(78天)
		新竹 56 Hsinchu 56	Ⅵ：14(79天)	Ⅵ：24(78天)	Ⅵ：19(90天)	(82天)
	收穫期 Date of harvesting	矮脚尖 Aichiaw-chien	Ⅶ：11(106天)	Ⅶ：15(99天)	Ⅶ：13(114天)	(106天)
		新竹 56 Hsinchu 56	Ⅶ：11(106天)	Ⅶ：29(113天)	Ⅶ：22(123天)	(114天)
第二期作 2nd crop	插秧 (月：日) Transplanting (month:day)		Ⅷ：15	Ⅷ：16	Ⅷ：7	
	出穗期 Date of heading	矮脚尖 Aichiaw-chien	Ⅹ：21(67天)	Ⅹ：11(56天)	Ⅹ：4(58天)	(60天)
		新竹 56 Hsinchu 56	Ⅹ：17(63天)	Ⅹ：16(61天)	Ⅹ：15(69天)	(64天)
	收穫期 Date of harvesting	矮脚尖 Aichiaw-chien	Ⅺ：27(104天)	Ⅺ：21(97天)	Ⅺ：12(97天)	(99天)
		新竹 56 Hsinchu 56	Ⅻ：6(113天)	Ⅻ：7(113天)	Ⅺ：26(111天)	(112天)

註 Note：括孤內數字爲插秧後日數 The figure in the parentheses are days after transplanting

圖1. 肥料處理對水稻產量之影響（十二個試驗之平均產量公噸/公頃）

Fig. 1. Effect of fertilizer treatments on the yields of rice(mean yields of 12 experiments ton/ha)

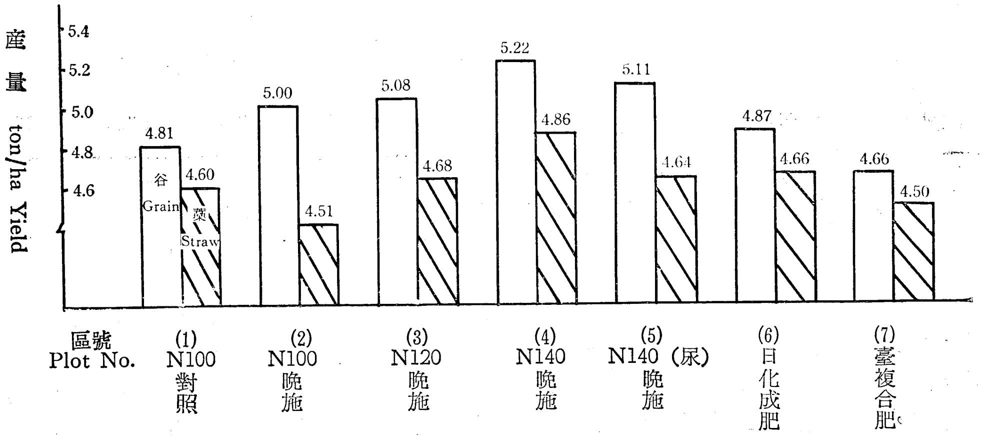


圖2. 十二個試驗之各肥料處理區稻谷產量指數（對照區做爲100）

Fig. 2. Indices of grain yields of the fertilizer treatmet plot of 12 experiments (taking the control plot as 100)

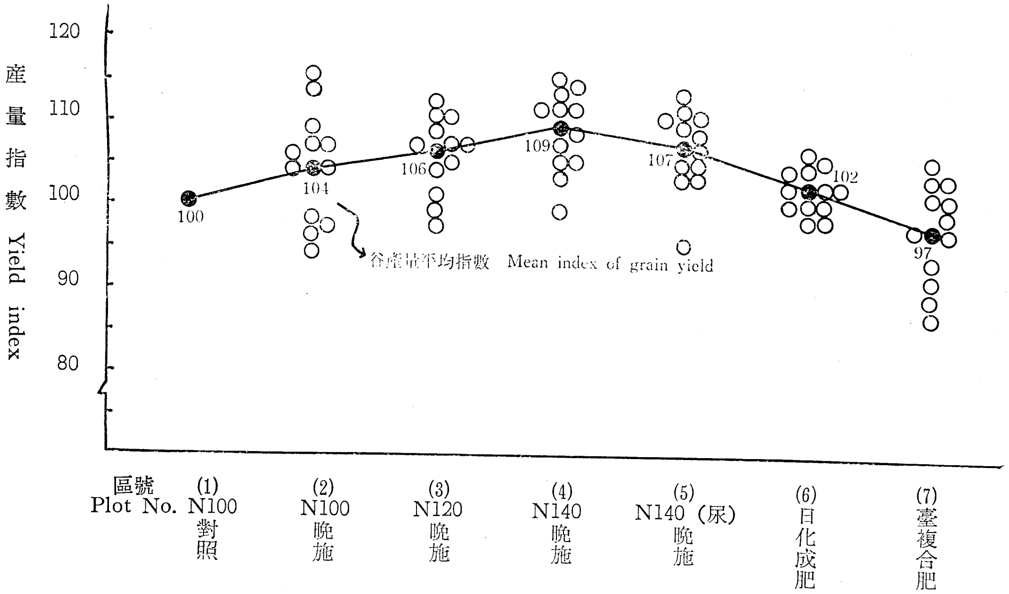
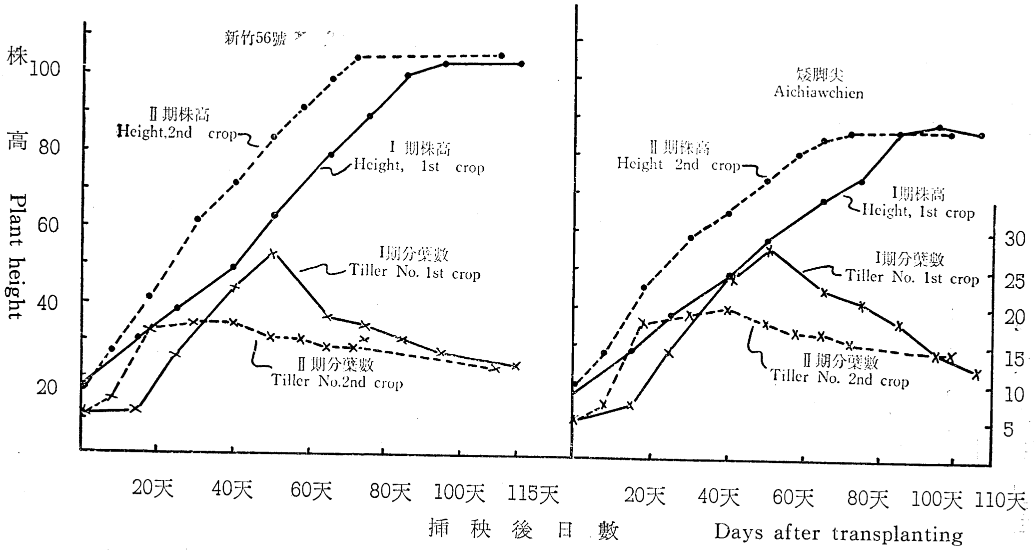


圖3. 新竹56號及矮脚尖在兩期作之生育情況

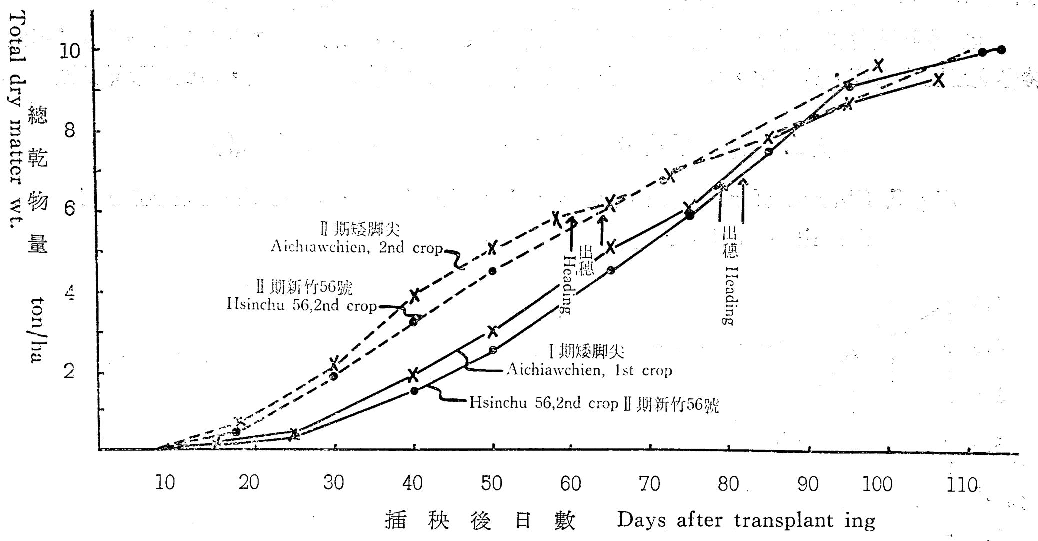
Fig. 3. The tiller number and the height of two rice varieties, Hsinchu 56 and Aichiawchien, grown in the two crop seasons



由圖1及2可看出各肥料處理區之十二個試驗平均水稻產量及其指數之比較。一般農家之慣行氮肥施用法，即對照區之 N100 公斤/公頃分三次施用與同量氮肥分六次施用，即第二處理之晚期施肥區比較時，前者谷產量4.81公噸/公頃，而後者5.00公噸/公頃得增產4％。若氮素施肥量提高，再配合晚期施用時，如第3處理 N120公斤可得增產6％，而第4處理 N140 公斤可得增產9％。

圖4. 新竹56號及矮脚尖在各時期之水稻總乾物生產量（公噸/公頃）

Fig. 4. The dry matter production of two rice varieties, Hsinchu 56 and Aichiawchien at successive growing stage (ton/ha)



近年來農復會補助農林廳所屬各改良場之水稻肥料試驗多處，其結果（4）表示氮肥之分施或穗肥之施用效果毫無疑問，但由各地環境之不同，對於如何分施，各時期之施用量應該多少尚無定論。林銅鐘氏（5）曾綜合歷年來之試驗成果而報告，穗肥施用均有80%之機會可獲得增產，其增產率約在10%左右，其穗肥施用量以20～25公斤/公頃，即全部氮肥之20—25%爲適。鑑於氮肥對水稻之重要性，氮肥施用技術及分施方法需要繼續研究改進。本試驗之施肥方法爲氮肥總施量之40%，作爲四次之晚期施用包括出穗前約25天之穗肥，齊穗期之粒肥及成熟期之少量追肥等。此種施肥法與已往本省之施肥法不同，係一種新的嘗試，至值得檢討。按日本近年來之稻米增產據施肥技術之改進所貢獻的不少（6），其氮肥施用法在温暖地區，晚期施用量之比率曾佔全部氮肥之40%以上時亦得增產效果（7）。又松島氏（8）之施肥技術近來頗被接受，他報告各時期之氮肥之重要性，提出氮素追肥之V字型多收理論（9）即水稻生育中期，穗首分化期（營養成長期與生殖成長期之中間）之氮肥施用可減低水稻澱紛含量及增加不受精谷粒及株高而可引起減產。此時期需要注意氮素之過剩。所以本試驗處理注重於生育中期缺氮，配合晚期之多氮施用，究明在本省土壤之效果如何。試驗結果如上述晚期施肥可得增產並氮肥施用量增多時，其效果愈甚。譬如 N140 公斤/公頃時增產9%，但超過一般施肥量的多量氮肥，若在一般施肥法施用時，是否可得增產尚有疑問，且有減產之危險。總言之，此結果指示氮肥施用量，若配合晚期施用者，大可增多，也許超過 N140 公斤/公頃尚可增產。換言之，已往之氮肥施用適量在 N80～120 公斤/公頃之觀念可能需要修改，即水稻施肥適量由施肥技術之改進可能會大大的提高，以達增產之目標。

關於硫銨與尿素之比較，由圖1及2之處理4（硫銨 N140 區）與處理5（尿素 N140 區）可知，前者各產量5.22公噸/公頃，後者各產量5.11公噸/公頃。若硫銨區作爲100時，尿素區指數爲98，相差2%，過去農試所進行六年之硫銨、尿素比較田間試驗亦得相同結果（10），即尿素對水稻肥効比硫銨差2%。使用土壤滲濾水裝置 Lysimeter 進行之硫銨與尿素肥料比較試驗四年平均結果（11），谷產硫銨區作爲100時，尿素區爲97。水稻對硫銨之氮素吸收率高於尿素，前者爲38%後者爲33%，但兩者肥料之氮素土壤滲濾損失率各約6%相差甚微。雖然同樣之氮素施用之下，硫銨比尿素略優，但使用尿素量增多時，尿素肥効可能達到與硫銨相同境地。

第7處理之臺製化成肥料區爲臺灣肥料公司出品，以尿素與磷鉀肥混合製造之16—8—12 配方複合肥料，其谷產量指數爲97，比對照區(硫銨)差3％，第6處理之日製化成肥料區爲日本日產化學工業株式會社出品之15—15—10配方，磷銨系之化成肥料。其谷產量指數102，比對照區硫銨略優2％。磷銨系肥料可能易被保持水田土壤中，並由於氮素損失較少，所以肥效較高。

關於本試驗所使用之兩種品種，新竹56號及矮脚尖兩期作之生育狀況列於圖3及圖4。將田間試驗各處理區之株高，分蘖數，總乾物量（包括稻藁及稻谷）之平均列於圖表，由此可以見此兩品種在

圖5. 對照區及晚施區之稻藁氮濃度之變化（N％）

Fig. 5. Change of nitrogen concentrations in rice straw at the control and the nitrogen later application plots

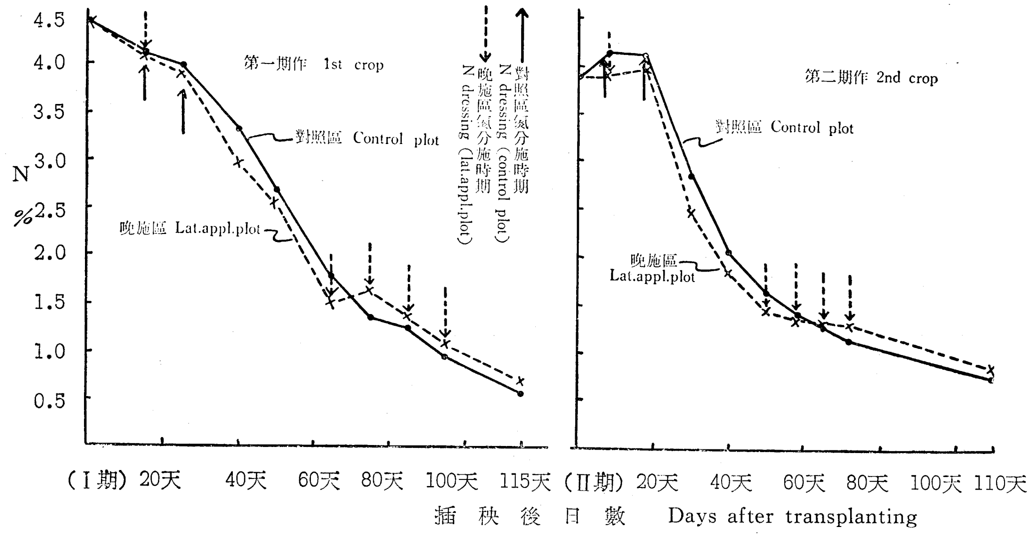
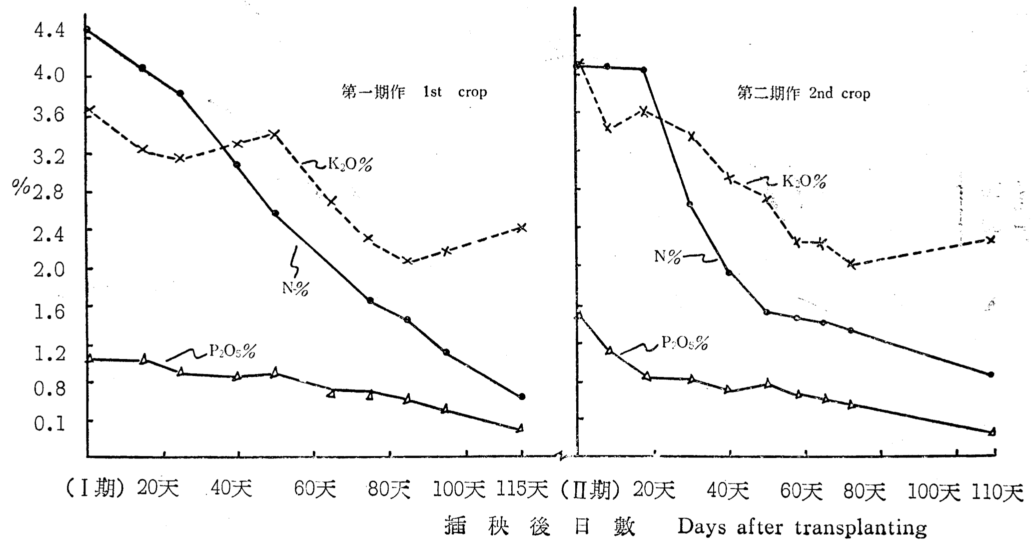


圖6. 稻藁之三要素濃度之變化（N. P_2O_5及K_2O％）

Fig. 6. Change of concentrations of nitrogen, phosphorus and potassium in rice straw



兩期作之差異如何。一般水稻插秧後營養生長期中因第二期作前期溫度較高，其水稻生育較在第一期作時爲旺盛，即株高，分蘖數及乾物生產量良好。但至於生殖生長期，第二期作水稻比第一期作水稻生育較差，即乾物生產量少，因之谷產量亦少。分蘖盛期第一期作約在插秧後50天，第二期作30天。矮脚尖比新竹56號分蘖數多，株高低而前期乾物量生產多，但後期轉遜。

圖7. 對照區及晚施區之水稻氮吸收量（氮N kg/ha）

Fig. 7. Amounts of nitrogen absorbed by rice plants at the control and the nitrogen later application plots

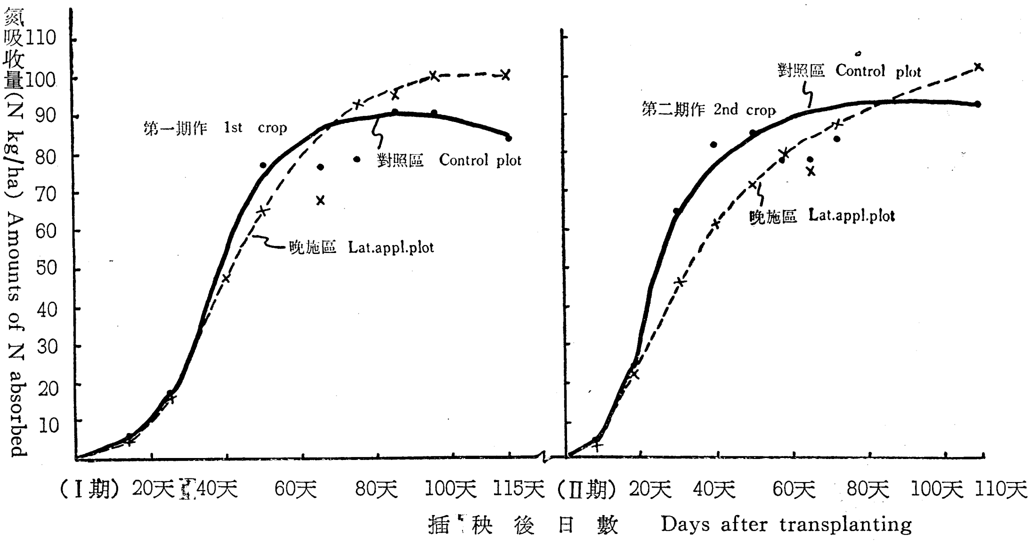


圖8. 水稻在兩期作之三要素吸收量

Fig. 8. Amounts of three elements absorbed by rice plants in the two crop seasons

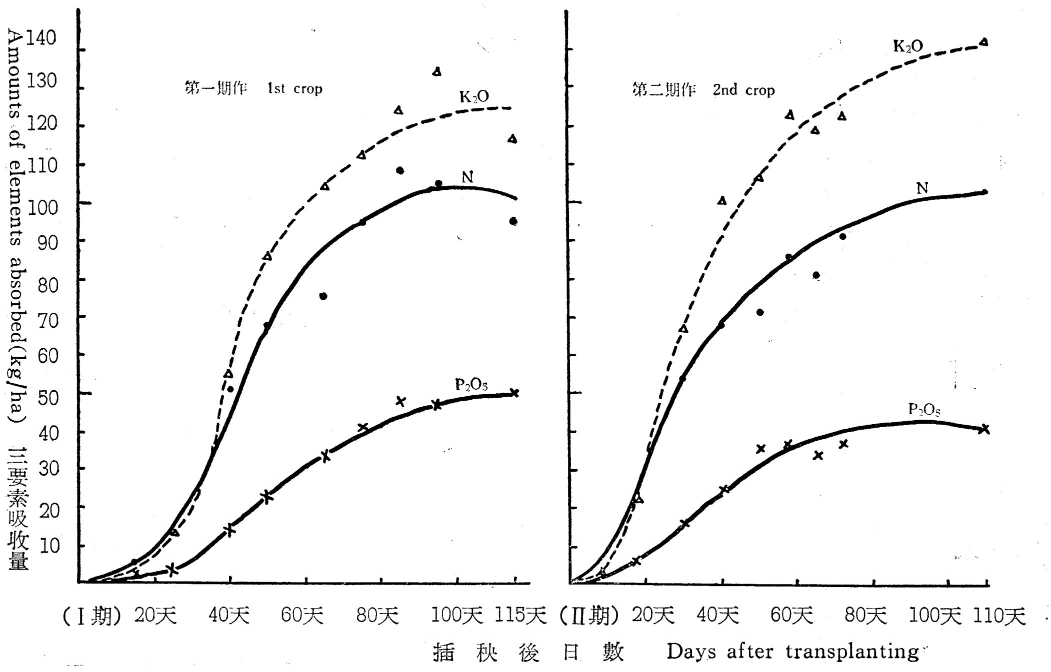
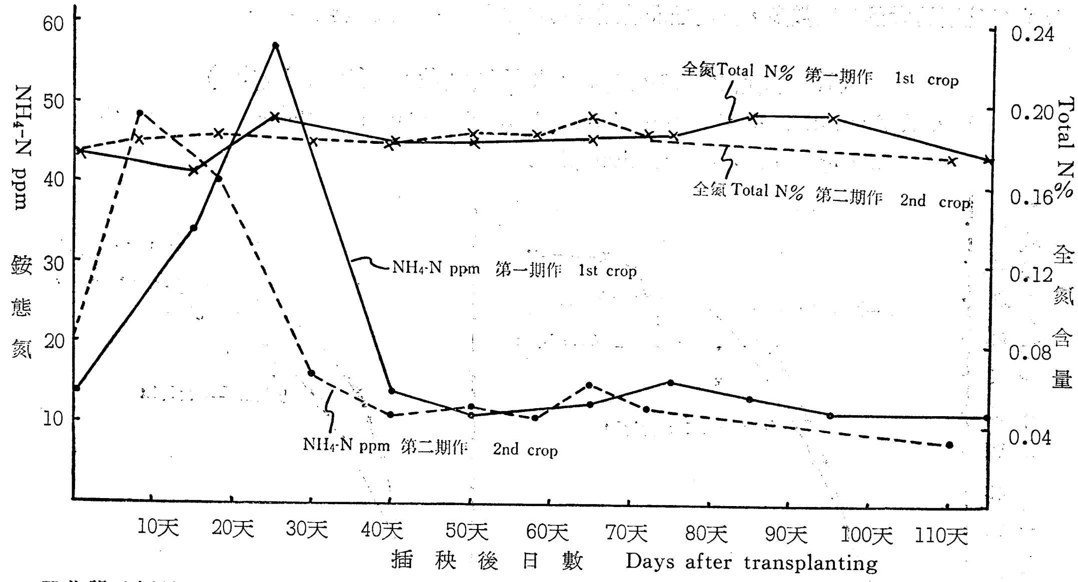


圖9. 水田土壤中全氮含量及銨態氮含量之變化（乾土中全N%及NH_4-Nppm）

Fig. 9. Change of total and ammonium nitrogen contents in the paddy soils(T. N% and NH_4-N ppm on dry soil basis)



Ⅱ化學分析結果

由插秧至收穫期間分爲十次，分別採取各處理區樣本，分析水稻之三要素、氮、磷、鉀濃度，調查各時期之三要素濃度之變遷及水稻對三要素之吸收情況。

第1處理，對照區及第2處理，晚施區之稻藁氮濃度之變化將其三處試驗，兩個品種之平均結果列於圖5。由圖5之結果可看出在同量之氮素量即 N100 公斤施用之下，對照區與晚施區之氮濃度變化有明顯之不同趨向，即對照區前期氮濃度較高，但後期變爲較低。由前述產量結果所知晚施區比對照區在十二個試驗之平均結果可得稻谷增產4%。此增產之原因是否因由水稻生育後期保持高的氮濃度所致，留待求進一步研究證明，不過按過去之研究報告（12）表示氮施用可提高水稻之氮濃度及光合作用效率，所以對稻谷增產似有幫助。又由圖5可知以不同施肥方法可控制稻藁之氮濃度，在幼穗形成期第一期作（約插秧後65天）及第二期作（約插秧後50天）之對照區氮濃度各爲1.70%及1.65%，而晚施區氮濃度各降低爲1.5%及1.44%，即相差0.2%。晚施區水稻在此時期之缺氮情況之下，氮肥之繼續施用可得稻谷之增產。

圖6表示各試驗地各處理區之稻藁之平均三要素濃度之變化。一般稻藁之三要素濃度插秧以後漸漸降低，至收穫期其濃度爲最低。但水稻在成熟期對鉀尚有多量吸收，所以稻藁鉀濃度在成熟期有提高之現象。

圖7表示在同量氮素 N100 公斤施用之下第1處理對照區與第2處理晚施區之水稻之氮肥吸收量之比較。在第一期作及第二期作都是同樣，在前期之水稻氮吸收量爲對照區較多，但在後期晚施區之氮肥吸收量變爲較多，至收穫時晚施區比對照區在第一期作多了17公斤/公頃，第二期作多了 10公斤/公頃之氮素之吸收量。若如何使氮肥被水稻完全吸收利用之問題爲稻谷增產之一個途徑時，採取此晚期施肥法確實使水稻吸收更多之氮肥，以致增產。圖8爲平均水稻三要素吸收量之情況。在收穫期之平均三要素吸收量爲 N—P_2O_5—K_2O 104—45—130 公斤/公頃 。分別由各處理區之水稻三要素吸收量觀之，一般氮肥之晚施及多施使水稻氮吸收量增加之外，稻藁及稻谷之鉀濃度亦增加，即促進水稻對鉀之吸收。

由表7之結果可看出氮肥之晚施或多施均可增加稻藁及稻谷之含氮量，即可得蛋白質含量較高的

稻谷，將各處理區之水稻三要素含量之平均做爲兩個品種新竹56號及矮脚尖之比較，列於表8，矮脚尖之藁谷之三要素含量均比新竹56號爲高，即矮脚尖對三要素之吸收比新竹56號强，尤其矮脚尖稻谷之氮含量較高，即蛋白質含量較高。

各時期所採取之土壤樣本，分析其氮含量之結果顯示，土壤中全氮含量在各時期之變化不大，產量最高之樹林土壤之全氮含量比其他土壤爲低，平均0.16%。桃園土壤爲0.18%。羅東土壤爲0.21%。關於土壤中銨態氮（NH_4—N）含量，各處理間差異很小，各時期之變化較大。將各地之平均結果列於圖9。土壤中銨態氮含量秧挿後漸漸增加，第一期作 30 天後，第二期作10天後達到最高，即由 15ppm 增高至 50～60ppm，然後漸漸減低而維持 12ppm 左右。硝酸態氮（No_3—N）有時 1～2 ppm，時常不能檢出。

表7. 不同處理區之水稻氮素含量（N%）

Table 7. Nitrogen content of rice grown at the different fertilizer treatments.

品種 Variety	期作 Crop	處理 Treatment / 地點 Locality	稻藁 Straw 1.N 100 對照	2.N 100 晚施	3. N120 晚施	4. N140 晚施	稻谷 Grain 1. N100 對照	2. N100 晚施	3. N120 晚施	4. N140 晚施
新竹五六 Hsinchu 56	第一期 1st crop	樹林	0.62	0.71	0.76	0.91	0.96	1.14	1.26	1.30
		羅東	0.50	0.58	0.64	0.72	1.21	1.07	1.21	1.21
		桃園	0.70	0.81	0.77	0.82	1.10	1.14	1.14	1.16
		平均	0.61	0.70	0.72	0.82	1.09	1.12	1.20	1.22
	第二期 2nd crop	樹林	0.86	0.84	0.91	0.90	1.10	1.15	1.16	1.19
		羅東	0.76	0.76	0.83	0.94	1.08	1.18	1.23	1.34
		桃園	0.84	0.83	0.90	0.95	1.31	1.35	1.33	1.35
		平均	0.82	0.81	0.88	0.93	1.16	1.23	1.24	1.29
	總平均		0.72	0.76	0.80	0.88	1.13	1.18	1.22	1.26
矮脚尖 Aichiawchien	第一期 1st crop	樹林	0.53	0.73	0.68	0.71	1.44	1.59	1.40	1.63
		羅東	0.36	0.50	0.59	0.68	0.91	1.23	1.23	1.31
		桃園	0.74	0.77	0.93	0.97	1.37	1.40	1.45	1.51
		平均	0.54	0.67	0.73	0.79	1.24	1.41	1.36	1.48
	第二期 2nd crop	樹林	0.65	0.72	0.77	0.81	1.09	1.15	1.16	1.19
		羅東	0.69	0.85	0.89	0.96	1.31	1.41	1.58	1.57
		桃園	0.91	0.88	0.93	1.00	1.41	1.53	1.56	1.56
		平均	0.75	0.82	0.86	0.92	1.27	1.36	1.42	1.44
	總平均		0.65	0.75	0.80	0.86	1.26	1.39	1.39	1.46

表8. 兩水稻品種新竹56及矮脚尖之三要素含量 (N. P_2O_5, K_2O%)

Table 8. NPK contents of two rice varieties, Hsinchu 56 and Aichiawchien

品種 Variety	期作 Crop	地點 Locality	稻藁 Straw			稻谷 Grain		
			N %	P_2O_5 %	K_2O %	N %	P_2O_5 %	K_2O %
新竹五六 Hsinchu 56	第一期 1st	樹林	0.70	0.266	2.53	1.12	0.616	0.47
		羅東	0.56	0.254	2.14	1.12	0.680	0.41
		桃園	0.73	0.291	1.87	1.08	0.655	0.37
		平均	0.66	0.270	2.18	1.11	0.650	0.42
	第二期 2nd	樹林	0.88	0.250	2.02	1.14	0.614	0.65
		羅東	0.81	0.167	2.36	1.23	0.584	0.34
		桃園	0.87	0.206	2.22	1.29	0.646	0.46
		平均	0.85	0.208	2.20	1.22	0.615	0.48
	總平均 Mean		0.76	0.239	2.19	1.17	0.633	0.45
矮脚尖 Aichiawchien	第一期 1st	樹林	0.65	0.284	2.79	1.45	0.737	0.43
		羅東	0.52	0.387	2.26	1.14	0.740	0.39
		桃園	0.81	0.282	2.12	1.39	0.742	0.40
		平均	0.66	0.318	2.69	1.33	0.740	0.41
	第二期 2nd	樹林	0.71	0.236	2.35	1.14	0.614	0.61
		羅東	0.79	0.364	2.29	1.38	0.637	0.39
		桃園	0.95	0.282	2.31	1.51	0.643	0.49
		平均	0.82	0.294	2.32	1.34	0.631	0.50
	總平均 Mean		0.74	0.306	2.51	1.36	0.686	0.46

四、摘　　要

使用兩個水稻品種，新竹56號及矮脚尖於羅東、桃園、樹林三處不同土壤進行田間肥料試驗，探求水稻氮素營養與產量之關係而闡明氮肥之晚期施用效果。此氮肥之晚施處理為全部之氮肥用量之百分之六十做為基肥及第一次追肥另百分之四十施用於水稻幼穗形成期以後即生殖生長期中施用。本試驗使用兩品種，三處試驗地，57年第一期作及第二期作，即共有十二個之田間試驗所得之結果如下：

1.同量氮肥 N100 公斤/公頃施用之下，晚施區比較對照區之慣行施肥可得稻谷增產4 %。多氮配合晚施即 N120 公斤/公頃時可得6 %增產，而 N140 公斤/公頃時可得9 %增產。使用晚期施肥技術可能提高原來之氮肥施用適量而得增產。

2.兩品種對多氮晚施都表現顯著的稻谷增產效果。第一期作新竹56號得增產12%，矮脚尖6%，但第二期作新竹56號6%，矮脚尖11%。平均稻谷產量兩品種間差異甚微，即新竹56號 5.00公噸/公頃，矮脚尖4.93公噸/公頃。

3.同量氮肥 N140 公斤/公頃施用之下，比較硫安與尿素之效果時，硫安區之谷產量爲5.22公噸/公頃，尿素區爲5.11公噸/公頃，相差2%。

4.同量氮肥 N100 公斤/公頃施用之下，比較硫銨與磷銨系複合肥料（日製15—15—10）及尿素系複合肥料（臺製16—8—12）之肥效，其稻谷產量指數硫安爲100時，磷銨系複合肥料 102，尿素複合肥料97。

5.稻谷產量高的氮肥晚施區之水稻在生育前期之稻稾濃度比對照區者爲低，但生育後期變高。氮肥晚施方法，使水稻在營養生長與生殖生長之中間降低氮濃度，即引起氮缺乏，而生殖生長期間中，一直保持氮高濃度。此種水稻氮營養狀態，似可得稻谷增產。

6.氮肥之晚施及多施使水稻氮吸收量增加之外，稾谷鉀濃度亦增加，即促進水稻對鉀的吸收。

7.矮脚尖對三要素之吸收比新竹56號爲强，尤其矮脚尖稻谷之氮含量較高，即蛋白質含量較高。

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STUDIES ON THE TECHNIQUES OF NITROGEN FERTILIZATION OF RICE PLANTS (PART 1) EFFECT OF THE LATE TOP-DRESSING OF NITROGEN ON THE YIELD AND NUTRIENT UPTAKE OF RICE PLANTS

by

T. F, CHIU and W. L. HUANG

Summary

Two rice varieties, Hsinchu 56, Japonica type and Aichiawchien, Indica type, were used in the field fertilizer experiments at three sites, Lotung slate alluvial soil, Taoyuan latosol, Shulin sandstone shale alluvial soil, in order to investigate the relationship between the plant nitrogen status and the yield of rice. Special emphasis was laid on the effect of the late top-dressing of nitrogen that is 40% of total amount of nitrogen was applied after the stage of the panicle primodial formation. The results obtained from twelve experiments including two varieties, three sites, two crops were as follows:

1. The grain yield of the nitrogen late top-dressing plot was increaced 4% as compared with that of the control plot under the same amount of nitrogen application, N 100 kg/ha. The grain increment of the late top-dressing was 6% at N 120 kg/ha plot and 9% at N 140 kg/ha plot. The optimum nitrogen requirement will be increased and the better yield will be obtained if the nitrogen late top-dressing method is used in paddy fields.

2. Significant effectiveness of the high nitrogen late top-dressing on grain yield was observed for both varieties. In the first crop, 12% of grain increment was obtained for Hsinchu 56 and 6% for Aichiawchien, while in the second crop, 6% for Hsinchu 56 and 11% for Aichiawchien. The average grain yield of the two varieties was quite close, that is 5.00 ton/ha for Hsinchu 56 and 4.93 ton/ha for Aichiawchien.

3. In comparison of ammonium sulfate and urea under the N 140 kg/ha application, the grain yield of the ammonium sulfate plot was 5.22 ton/ha while that of the urea plot was 5.11 ton/ha showing 2% difference in grain yield.

4. Taking the grain yield of ammonium slufate as 100 under the same amount of nitrogen N 100 kg/ha application, that of the compound fertilizer of ammonium phosphate type (grade 15-15-10) was 102 and the compound fertilizer of urea type (grade 16-8-12) was 97.

5. The nitrogen content of rice straw of the high nitrogen late top-dressing plot which had the highest yield was lower at the early growing stage, however, the nitrogen content became higher at the later growing stage as compared with that of the control plot. The late top-pressing method induced the lower nitrogen content of straw showing nitrogen deficient status at the middle stage of rice growing period, and after that the

nitrogen content became higher than that of the control plants through reproductive stage. This nitrogen status seems to be better for rice to produce higher yield.

6. The nitrogen late top-dressing or high nitrogen application had rice plants increase nitrogen content as well as potassium content. The increase of nitrogen absorption seemed to promote potassium absorption.

7. More absorption of three elements by Aichiawchien than by Hsinchu 56 was observed. Higher nitrogen content, presumably higher protein content, was found especially in grains of Aichiawchien.

旱作水稻根系在不同土層吸水量的品種間差異(預報)

吳振能・藍　調

一、前　言

水稻的栽培，原以灌溉方便的水田為限。在缺水地區以普通方法栽培水稻時，因未能充份灌漑，即不能適應。但以水稻的旱地栽培方法，則可改善不少。因此為便於將來推廣這種栽培方法，首先對於旱作水稻的吸水特性宜加研究，然後針對其吸水特性調節灌漑方法，以提高產量，使缺水地區栽培水稻的困難得以解除。

旱作灌漑的原則之一是當灌漑時務使水分滲透土中根系分佈範圍，但不致發生重力水而流失。然而旱作水稻根系的分佈情形及其從不同土層吸收水量的差別（所謂吸水型）如何，又其品種間的差異都尚待研究。

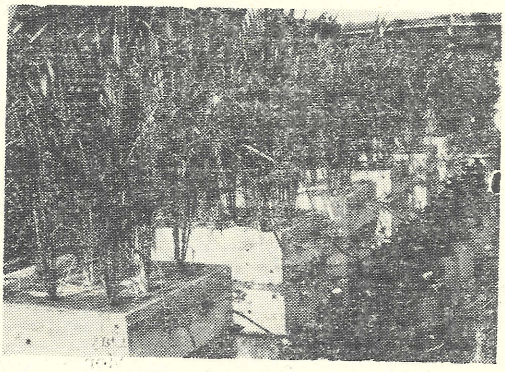
本報告係此一研究的初步結果。其他各方面的有關問題的研究，尚在進行中。

二、研究方法

本研究在玻璃室進行，但除颱風來襲時外，經常開放門窗，只留防蟲紗網，且於晴天高温時以抽風機調節室温，使之接近自然狀態。

供試品種：第一期作為臺農選1號、臺農選3號及臺中186號。第二期作用臺中186號、臺中65號及嘉南2號。

不同土層的吸水量乃以三層式自動灌水裝置，每天上午九時以各層貯水瓶的消耗水量，分別測定之。



照片1：旱作水稻在不同土層吸水量的研究實況

The real sight of water absorption measurement with auto-irrigators for lowland rice cultivated on upland

其裝置的平面為60×60公分，各層的深度是20公分。各層中央埋設石膏電極一個，並將電線導出外面，以便測定土壤含水量。每一裝置組成後，調節其土壤含水量為最大容水量的75～80%（旱田狀態）而進行研究。每套裝置的底部，內側及上層土面都鋪蓋塑膠布；土面的塑膠布乃於稻種發芽後打洞，使其伸出外面，其後隨著稻株的發育而剪大洞徑，必要時以化學纖維堵塞空隙，盡量防止水分的發散。

每品種用上述裝置兩套，重複2次；每套播種9穴，待發芽後每穴留一健苗，以栽培9株水稻，如照片1所示。

不同土層根系的分佈量乃於收穫時，將裝置按層解開，細心檢取各層的稻根，待風乾後測定。

在玻璃室內設置百孔箱，內裝各種溫度計，每

天按時觀測最高及最低氣溫與空氣的相對濕度，以及天氣概況等，以資考察水量的變化受氣象因子的影響情形。

另一方面，每十天調查水稻株高、分蘗數及生葉數等，以便查考每一貯水瓶消耗水量的正確性。

三、研究結果

本研究供試水稻第一期作於民國58年3月28日播種於實驗裝置，而於同年7月16日結束，其時臺農選1號及臺中186號爲出穗期間，但臺農選3號尚未出穗。第二期作於 58年8月4日播種，至59年1月 4 日結束（成熟期）。第二期作，因受9月27日艾爾西颱風的影響，平均氣溫也降低了 5 °C。因此自9月27日至10月6日之間，上層（0～20cm） 的吸水量減低。然因此一時期爲水稻發育中期，植株不久即行恢復，故就全期而言，其影響並不甚大。

茲將初步結果概述於下：

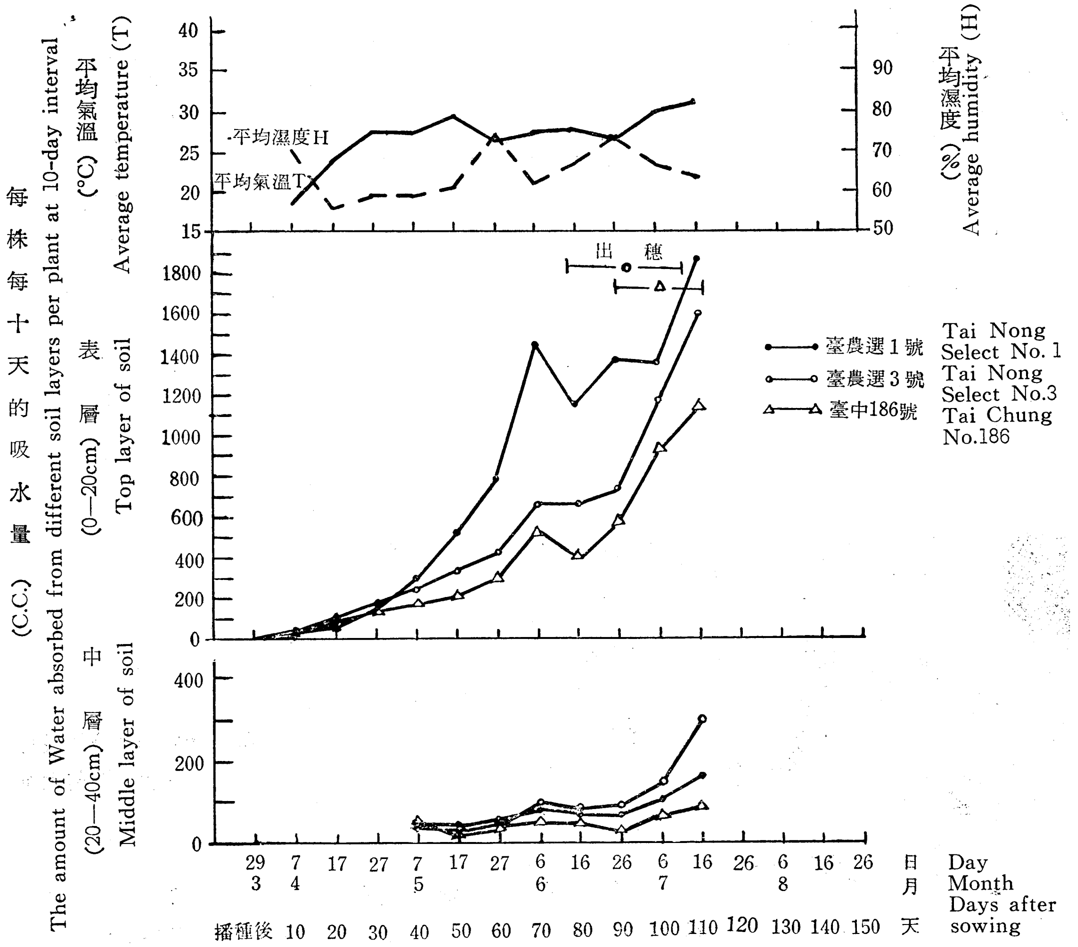


圖1：旱作水稻根系在不同土層吸水量的變化與氣溫及濕度的關係（58年第1期作）

Fig.1: The water absorption of roots of lowland rice cultivated on upland from different soil layers as influenced by temperature and humidity (1st crop, 1969)

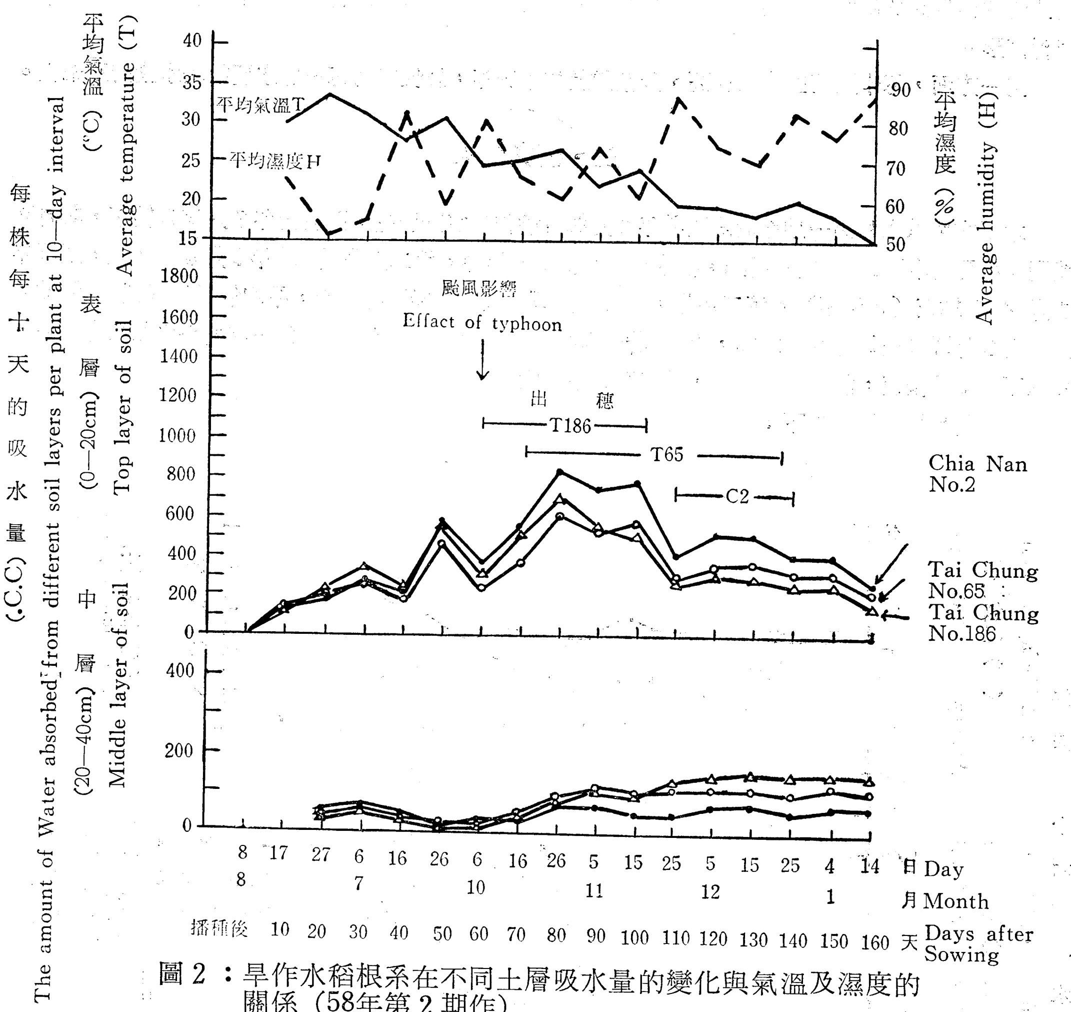


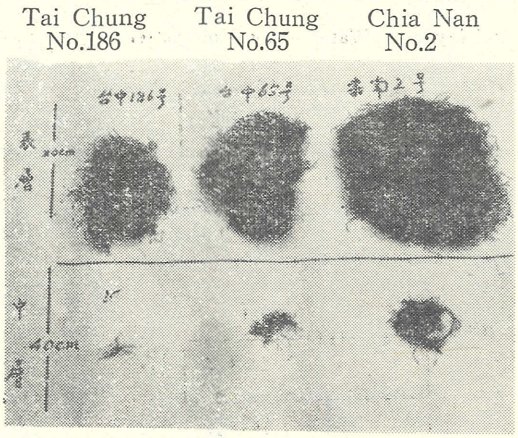
圖 2 ：旱作水稻根系在不同土層吸水量的變化與氣溫及濕度的關係 (58年第 2 期作)

Fig.2: The water absorption of roots of lowland rice cultivated on upland from different soil layers as influenced by temperature and humidity (2nd crop, 1969)

旱作水稻根系的分佈範圍 第一期及第二期共 6 品種，根系的分佈情形，示如圖3、4。在本研究之範圍內，第一及第二期作合計 6 個品種之稻根均未見有伸入下層 (40～60cm) 者。因此各圖均省去下層部份。

生育期間根系在不同土層吸水量的變化及其受氣象的影響情形 上層 (0～20cm) 的吸水量，從稻種發芽後隨著植株的生長而增加，至出穗期達到最高峰，然後因植株的老化而減少 (如圖 1、2)。本研究資料第一期作雖缺出穗期以後的部份，但據另以單層式自動灌水裝置研究結果 (擬另文報告)，如同上述。上層吸水量品種間的差異：第一期作很顯著，第二期作差異較小；晚熟種的吸水量大於早熟品種。第一期作的吸水量顯比第二期作大。此係因兩期作之間，氣象條件不同而影響水稻的發育，及第二期作後半段的溫度較低，直接影響吸水作用所致。此外應注意的是，出穗前後的吸水量受氣象因子，尤其是氣温的影響而敏感地變化。

中層 (20～40cm) 的吸水量：稻根未伸入中層之前，不從中層吸水。其開始吸水的時期，第一期作因溫度低，水稻初期發育較慢，於播種後約30天始見吸水。第二期作在高溫之下自第10天左右就



照片 2 ：旱作水稻根系的分佈情形
（9株的總根量）

The distribution of lowland rice roots cultivated on upland (total amount of 9 hills)

開始吸水。水稻生育期間中層吸水量變化的幅度，比上層小得多。上層吸水量大的品種，在中層的吸水量於出穗以後反而變小，如第一期臺農選1號及第二期嘉南2號，這點值得注意，其理由有待研究。

根系分佈型及吸水型　如圖3•4及照片2所示，分佈於上層的稻根，第一期作 92.1～97.5%，第二期作爲 98.4～99.9%（均以風乾根重表示）。稻根在中層分佈量對總根量比率的品種間差異，第一期作較大；第二期作差異很小。但是其實際發根量品種間的差異仍相當大（照片2）。

因大部份的稻根分佈於上層，故從上層吸收的水量，第一期作爲上中層總吸水量的 87.9～93.3%，第二期作爲80.1～89.8 %之高。中層的吸水量對總吸水量的百分比，以臺中 186 號來說，第二期作在高温之下大爲增高。

綜合上列試驗結果，可知旱作水稻根系從上層（0～20cm）土壤吸收大部份水量；但是中層

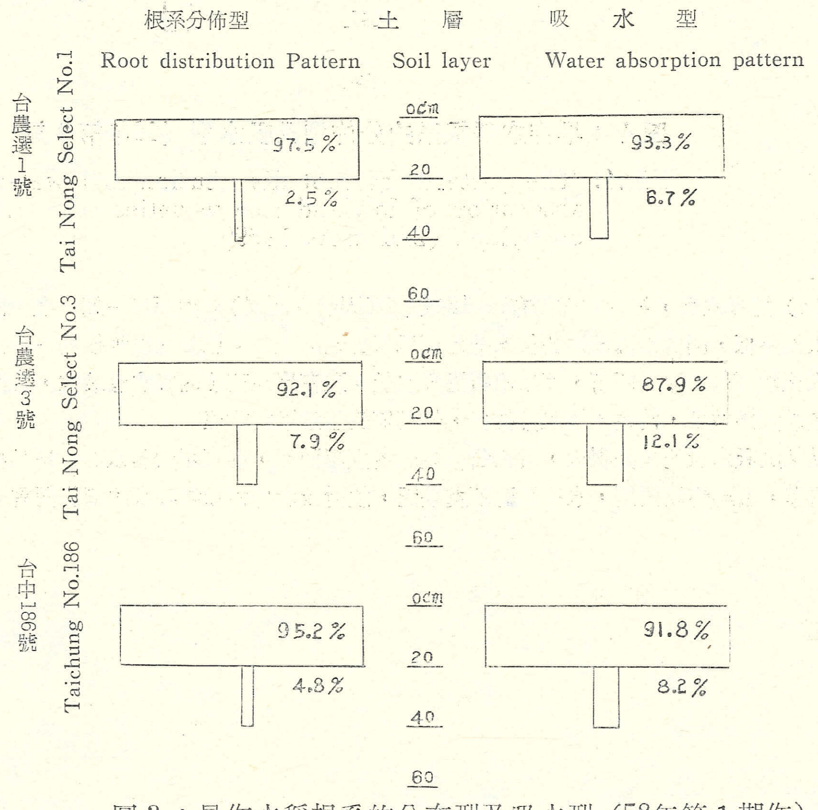


圖 3 ：旱作水稻根系的分布型及吸水型（58年第1期作）

Fig.3: The patterns of root distribution and water absorption of lowland rice cultivated on upland (1st crop, 1969)

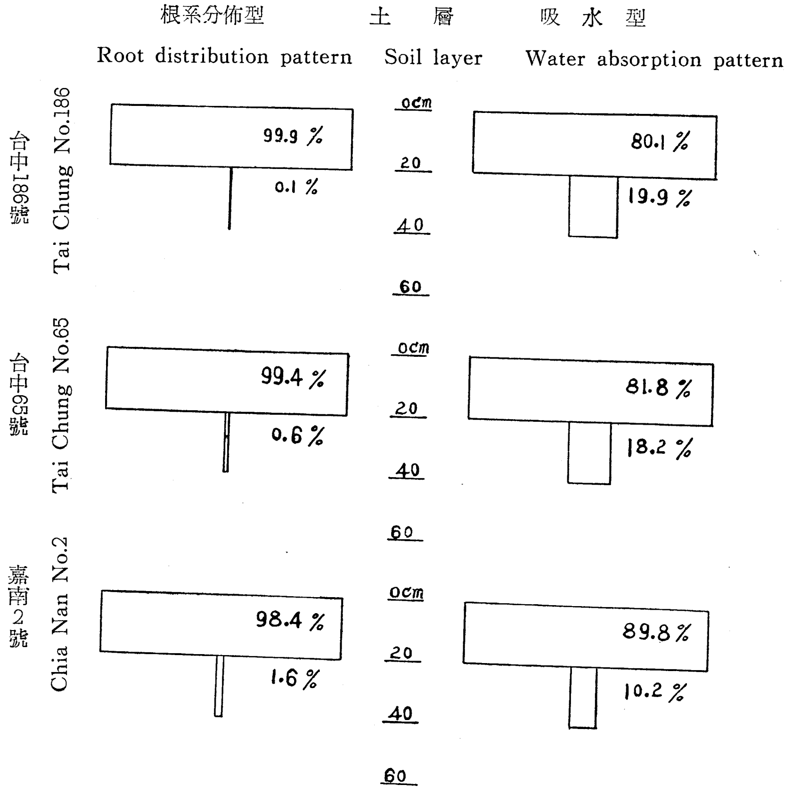


圖 4 ：旱作水稻根系的分佈型及吸水型（58年第 2 期作）

Fig.4: The patterns of root distribution and water absorption of lowland rice varieties cultivated on upland (2nd crop, 1969)

(20～40cm) 的吸水量，第一期作仍有7～12%之多(因品種而異)。然而第一期作在中南部乃是旱季，且地下水位降低，因此當灌溉時務使水分滲至稻根伸達的土層。但是在播種後約一個月之間，只使灌溉水滲入土壤 20cm深處即可，藉以節省灌溉水量。又在出穗前後的吸水量最大，且因氣溫稍微昇高，吸水量就大為增多，消耗土壤水分甚多，特別需要注意灌溉管理。

又因品種間吸水量的差異很大，就節省灌溉水的立場而言，應採用最省水的早熟品種。

第二期作，因為時值雨期，水的供應不虞缺乏，故對吸水特性和灌溉水的節省而言，較無問題。

STUDY ON THE WATER ABSORPTION OF LOWLAND RICE VARIETIES IN DIFFERENT SOIL LAYERS OF UPLAND (PRELIMINARY NOTE)

by

Chen-Neng Wu and Tao Lan

Summary

The study was conducted at Taiwan Agricultural Research Institute to determine the irrigation method for lowland rice varieties that cultivated on upland.

The three-layer-type auto-irrigators which can measure the amount of water absorbed by rice roots and the development of root system in different soil layers, were used in this study. The soil was divided into three layers of 0-20, 20-40 and 40-60 cm in depth. The soil moisture of every layer was controlled at the level of 75-80% of soil-water-holding-capacity. Nine hills of lowland rice for each of the three varieties in each crop season, wereplanted by direct seeding method on each auto-irrigator in the greenhouse. These auto-irrigators were covered with vinyl film so as to stop the water evaporation from their surfaces. The windows of the greenhouse were opened but covered by screens; and several air ventilators were used during day time to minimize the room temperature.

The results obtained in the first year are summarized as follows:

1. Six rice varieties tested in two crop seasons showed that there was no root penetrated into the bottom layer of the soil (40-60 cm).

2. The amount of root distributed in the top layer of the soil (0-20 cm), was 92.1-97.5% (differed by variety) in the first crop, and 98.4-99.9% in the second crop. Accordingly, 87.9-93.3% of total amount of water absorbed by roots of a rice hill, was from the top layer of the soil in the first crop; and 80.1-89.8% in the second crop.

3. The date that rice roots began to absorb the water in the middle layer of the soil (20-40 cm), was about 30 days after sowing in first crop; then it was around 20 days earlier in the second crop than in the first crop, because the rice roots of the second crop grew faster than that of the first crop under higher temperature condition.

4. The difference of total water amount absorbed by rice roots among varieties, was highly significant, i.e. the water consumption of early maturing variety was smaller than that of late maturing variety.

5. The water absorption by rice roots in the top layer of the soil before and after heading stage changed very sensitively according to the change of temperatures.

6. Based on the above facts and for the purpose of saving irrigation water, the amount of irrigation water has to be adjusted to the level just to moisten the soil layer of 0-20 cm for about 30 days after sowing in the first crop during which is a dry season and the underground water level is very low in the Midsouth of Taiwan. After one month, however, the irrigation water has to be increased to moisten the soil layers of 40 cm deep where the rice roots have reached in this study.

On the other hand, the early maturing varieties are recommended for the upland-type culture of lowland rice in the area that short of irrigation water.

Generally speaking, the second crop is grown during the wet season in Taiwan, so there is little to be considered for the lowland rice varieties cultivated on upland with regard to the irrigation problem.

水田雜草與水稻病害關係之研究

1. 水稻紋枯病在水田雜草寄主之考察

蔡　武　雄

前　言

水田雜草生長於稻田，直接影響水稻的發育與生長，間接導致病蟲害，尤其臺灣的熱帶性及亞熱帶性氣候，對雜草之繁殖非常適宜，據記載（1.2.3）臺灣水田雜草有一百多種。這些水田雜草常為病蟲害傳播的媒介。水稻白葉枯病病菌之寄主雜草已有9科20種（5）之多；傳播水稻毒素病之黑尾浮塵子類可在水田雜草產卵越冬（4）；傳播藁葉枯病之飛蝨(*Laodelphax Striataellus* Fallen）亦可在雜草上寄生（6）；紋枯病菌菌核在水中浮游，附着於水稻或雜草時就發芽侵入（7），故水稻病害往往與水田雜草有密切關係。

水稻紋枯病已往為本省第二期作主要病害，但近年來在第一期作亦普遍發生，有些地區其嚴重性並不亞於第二期作，故紋枯病在本省仍為威脅性的稻作病害。禾本科雜草與水稻植株往往不易分辨，故除草時未能徹底除去，直到雜草開花成熟時才易於識別，此時常可發現在雜草上發生與水稻紋枯病相同的病徵。其他非禾本科之水田雜草，其莖、葉亦可受紋枯病為害，但其病徵不易看出，然而這些受害的雜草，均可為紋枯病的傳染媒介。本試驗在尋找紋枯病在水田雜草上之寄主種類及其與水稻病害之關係，俾供今後防治本病的參考。

本試驗期間，蒙農藝系主任張萬來技正協助鑑定雜草，謹此誌謝。

材料與方法

一、寄主範圍之考察：

於水稻生長期間，收集水田雜草，種於植盆中，其後以培養於稻藁一星期之菌絲及稻藁置於每一種雜草之基部，以塑膠蓋蓋上，每天噴以水霧（三次），以保持濕度，4天以後，檢查受害情形，並記載受害之雜草名稱、科名及受害部位。

二、菌核、病組織與水稻及雜草交互接種：

將試驗一所得雜草之病組織剪下，置於盛於濾紙之培養皿内，注入無菌水，保持濕度，將培養皿放在 30°C 的定温箱中，4天以後即有菌核形成。將各種雜草上所形成的菌核（儘取大小相近者）或病組織接種於水稻葉鞘内，4天以後，觀察受害情形。另以稻藁上形成之菌核接種在水稗及毛穎雀稗上，同樣觀察其受害情形。

試驗結果

一、寄主範圍的考察：

觀察結果如表一。紋枯病菌在雜草之寄主，主要為禾本科雜草，禾本科雜草上所形成的病徵與在水稻植株上所形成的病徵相似，故在未開花結果以前，禾本科雜草與水稻植株不易分別，除草時未能拔除，常與水稻同被紋枯病寄生。其他非禾本科之雜草，亦可為紋枯病之寄主，其為害部位為莖葉或葉柄，受害以後變化成濕潤狀而枯萎，其病徵不易識別，與在水稻上所形成的病徵不同。將各種寄主雜草之病患部剪下以後，置於 30°C 之定温箱，經4天以後，除了鴨舌草（*Monochoria vaginulis* (*L.*) *Presl*）及 *Pista stroatistes* 外，均可產生菌核。將所得之菌核或病組織接種水稻之葉鞘以後

，均可產生紋枯病。

表一、 水稻紋枯病菌在雜草上之寄主

寄主名稱	學名	科名	為害部位
毛穎雀稗	*Paspalum conjagatum* Berg	禾本科 (*Gramineae*)	葉、葉鞘
細葉野稗	*Echinochloa crus-galli Beaur var. austro-japonensis* Ohwi	禾本科 (*Gramineae*)	葉、葉鞘
水稗	*Echinochloa crus-galli Beaur. Var. Candata (Roshev)* Kitagawa.	禾本科 (*Gramineae*)	葉、葉鞘
狗牙根	*Cynodon dactylon pers.*	禾本科 (*Gramineae*)	葉、葉鞘
畔茅	*Leptochloa chinensis* Nees	禾本科 (*Gramineae*)	葉、葉鞘
匍黍草	*Panicum repens* Linn	禾本科 (*Gramineae*)	葉、葉鞘
木虱草	*Fimbristylis miliacea* (Linn) Vahl	莎草科 (*Cyperaceal*)	葉、稈
球花蒿草	*Cyperus difformis* Linn.	莎草科 (*Cyperaceal*)	葉、葉鞘
螢藺	*Scirpus juncoides* Roxb. *Cyperus pilosus* Vahl	莎草科 (*Cyperaceal*) 莎草科 (*Cyperaceal*)	葉鞘、稈 葉、莖
鴨舌草	*Monochoria vaginalis* (L.) Presl.	雨久花科 (*Pontederiaceae*)	葉、葉柄
母草	*Lindernia pyxidaria All.* *Rotalaindica* (willd) Koehne	玄參科 (*Scrophulariaceae*) 千屈菜科 (*Lythraceae*)	莖、葉 莖、葉
四葉菜	*Marsilea quadrifolia* Linn	蘋科 (*Marsiliaceae*)	莖、葉、葉柄
半邊蓮	*Lobelia radicaus* Thunb.	桔梗科 (*Campanulaceae*)	葉
水萵苣	*Pistia stroatistes*		全株受害
滿天星	*Alternanthera sessilis* R. Br.	莧科 (*Amaranthaceae*)	葉
水龍	*Ludwigia peploides* (Kunth) *Reaven subsp. stipulacea(Ohwi)* Reaven	柳葉菜科 (*Denotheraceae*)	葉 葉
鱧腸	*Eclipta prostrata* (L.) Linn.	菊科 (*Compositae*)	葉
臺灣蚶殼草	*Hydrccotyle formosana* Masamune	繖形花科 (*Umbelliferae*)	葉

二、菌核、病組織與水稻及雜草交互接種

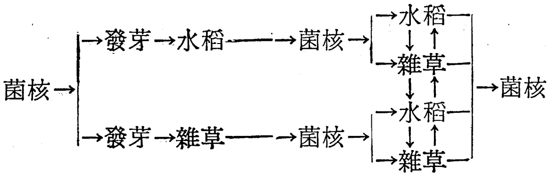
從雜草上所得到的菌核或病組織，接種在水稻的葉鞘上，對水稻均有致病性，尤其是禾本科雜草的菌核對水稻之致病性更强，其發病率達100%；其他雜草之病組織對水稻亦有致病性，僅是程度有强弱之別而已，至於在稻藁上所形成之菌核接種在水稗及毛穎雀稗之葉鞘上，其發病率達95及85%。接種結果詳見表二。

表二、 菌核、病組織與水稻及雜草交互接種情形

供試寄主	供試接種源名稱	接種源	接種莖數	發病莖數	接種葉鞘病斑大小
水稻	毛穎雀稗	菌核	20	20 (100%)	3.5×0.5cm
	細葉野稗	菌核	20	20 (100%)	1.2×0.3

	鴨舌草	病組織	20	6 (30.0)	0.6×0.3
	母草	菌核	20	11 (55.0)	0.9×0.3
	球花蒿草	菌核	20	12 (60.0)	1.8×0.3
	Rotala indica	菌核	30	30 (100)	1.4×0.4
	四葉菜	菌核	30	18 (60.0)	0.9×0.1
	半邊蓮	菌核	30	28 (93.3)	1.3×0.2
	木虱草	菌核	20	16 (80.0)	1.2×0.4
	滿天星	菌核	20	16 (80.0)	0.9×0.2
		病組織	20	10 (50.0)	0.6×0.2
	水龍	菌核	20	17 (85.0)	0.8×0.2
		病組織	20	8 (40.0)	0.5×0.3
	狗牙根	菌核	30	30 (100)	2.7×0.4
水稗	水稻	菌核	20	19 (95)	1.3×0.3
毛穎雀稗	水稻	菌核	20	17 (85)	1.5×0.4

紋枯病在水稻上係以菌核傳播；但今後研究紋枯病傳染媒介，應擴及水田雜草上，其傳染途徑可以下圖表示之。



討論與結論

水田雜草在傳播紋枯病上占有重要地位，尤其是禾本科雜草，常與水稻混雜生長於水田，不易識別，以致農民在除草時未能拔除，常感染紋枯病，作爲紋枯病之寄主，以菌核或病組織再媒介至水稻。在交互接種試驗時，由禾本科雜草上所獲得的菌核接種在水稻時，其發病率達100%；其他非禾本科雜草之菌核或病組織接種在水稻時均可使水稻發病。另由稻藁上形成之菌核接種在水稗及毛穎雀稗上，其發病率達95及85%，可見雜草對紋枯病傳染的重要性。

通常紋枯病之傳染媒介，僅注意到由水稻病患部所形成而遺落於田間之菌核，並未注意到雜草上所形成之菌核或組織亦能傳染紋枯病。故今後防治水稻紋枯病，該注意到水田中雜草或田邊溝渠邊之雜草，亦可爲紋枯病之寄主。故清除雜草，當可減少紋枯病之爲害。

摘　要

水稻紋枯病在雜草上之寄主，據本試驗結果，已有20種之多，其中以禾本科及莎草科最重要，其他有非禾本科之雜草，亦爲本病之媒介寄主。

以雜草上所形成之紋枯病核或病組織接種在水稻植株，均可使水稻致病，以水稻稻藁上形成之菌核接種在雜草上亦可使雜草致病，故紋枯病可由水稻傳到雜草，再由雜草傳到水稻。

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STUDIES ON THE RELATIONS BETWEEN WEEDS AND RICE DISEASES

I. OBSERVATIONS ON THE HOST RANGE OF RICE SHEATH BLIGHT FUNGUS (*PELLICUARIA SASAKII*) ON WEEDS

by

W. H. Tsai

Summary

In this experiment it was found that the host range of rice sheath blight fungus on weeds including 11 families 20 species. Among them, *Gramineae* and *Cyperaceae* were the most important ones.

The sclerotia or diseased tissues obtained from weeds produced typical symptoms of rice sheath blight on rice plants, whereas those sclerotia from rice straw developed typical sheath blight symptoms on *Gramineae* or diseased lesions on other weeds when inoculation was made. These results clearly demonstrated that the pathogen of rice sheath blight can disseminate from rice plants to weeds and *vice versa*.

REPORT ON RESEARCH OF RICE CROP PRETECTION FROM INSECTS IN VIETNAM, 1968-1969

BY Chia-hwa Tao*and Dinh-ngoan Ngo**

I. Introduction

Rice borers, leafhoppers and planthoppers have been found disastrous to rice crop throughout the rice-producing areas of South Vietnam. The infestation of these pests is closely connected with climatic conditions and multiple farming system. The writer have had an opportunity to study on the ecology of these pests and their control with chemicals in the pest two years in Vietnam. The results are presented below:

II. Study on ecological environment of rice borers

Rice borers are the common old enemy of rice in Southern Asia, and are considered rather rampant in other countries too. The seasonal outbreak of the borers is connected with three factors, namely, weather, preference of host plants and environmental conditions. Methods of control have become a serious problem as rice production program is being accelerated in Vietnam.

According to the ecology of the rice borers, the environmental conditions are more important than that of the weather climate, particularly in the Delta rice areas. The relative outbreak of rice borers in Vietnam is given in detail below:

Three species of rice borers are found in Vietnam, namely, paddy borer, *Tryporyza incertulas*, striped rice stem borer, *Chilo suppressalis*, and pink stem borer, *Seasmia inferens*. Besides rice the pink stem borer also attacks the corn, sugarcane, and sorghum, becasuse it belengs to omnivorous habits and has a better chance of survival and multiplication than monophagous paddy borer and oligophagous striped rice borer. Usually borers cause damage. The insects penetrate into the leaf sheath and crowed between the stem and leaf sheath, chewing tissues of rice stems and thus resulting the plants withered. The notable symptoms are "dead heart" at the tillering stage and "white head" at the heading stage. These symptoms, however, were rarely found in the last rice crop season, particularly in the Delta provinces.

After field study of the problem, the writers are of the opinion that the environment of Southern is not favorable for the multiplication of rice borers. The writers have found out that the high level of water in the paddy field during the raining season is fatal to their exsistance. Large quantities of the larvae would have been drowned before their

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getting into the leaf sheath.

The dry season during winter and spring when most of the land are desolated also helps check the spread of the insects. At this time, the borer would find it difficult to survive the long drought without host plants in the field, and its population should be drastically reduced. Some larvae could pupate in the old rice stubbles or old rice stems but the emergincing adults would face the same problem of having no host plants for laying eggs. The hot tropical temperature above 30°C would somewhat reduce hatching.

III. Observation in the outbreak of leafhoppers and planthoppers

Leafhopper and planthopper are increasingly regarded as major insects for rice crop in the rice-growing countries. Records showed that as high as 30-50% loss in rice crop was inflicted by green leafhopper in central Vietnam during 1960-1963. In recent years, hopper were found prevalent in central lowland in the summer of 1969. The new IR-8 variety seems more susceptible to them. Some 2,000 hectare of the rice crop in Phan-Rang area suffered a loss of 10-15%, while another 30 hectares suffered a total loss at harvest. The leafhoppers commonly found in Vietnam are rice green leafhopper, *Nephotettix bipunctatus cincticeps*, zigzag striped leafhopper, *Inazuma dorsalis*, and white winged leafhopper, *Erythroneura subrufa*, belonging to the family Cicadellidae. Planthoppers are such species as brown planthopper, *Nilalaparvata lugens*, white-back planthopper, *Sogatella furciferv*, and yellow planthopper, *Nilaparvata bakeri*, belonging to the family Delphacidae and flour planthopper, *Nisia atrovenosa* of the family Meenoplidae. The *N. bakeri* and *N. atrovenosa* were newly recorded in Vietnam. These insects damage the rice plants either by direct sucking of stem juice, which may results in loss of plant vigor or complete wilting of the plants, or by transitting virus diseases such as *Transitory yellowing*, *Yellow dwarf* and *Dwarf* or *stunt*, chiefly through *Nephotettix* spp., and *Grassy stunt* is transitted by *N. Iugens*.

The outbreaks of the leafhoppers and the planthoppers are depending largely on climatic and environmental conditions. Generally, these are more prevalent in central provinces than southern provinces. Planthoppers may become abundant this year, while in other year, leafhoppers may take its turn under favorable conditions.

Results of studies indicate that white-back planthopper is most adaptable under 29-30°C temperature and 80-85% humidity, and the brown and yellow planthoppers under a lower temperature and a higher humidity. This explains why the hoppers have been rarely reported in Delta region where temperature is usually higher. The depth of water in the paddy field and the velocity of wind, which help check the spread of the pests in tillering stage, bear upon their population, which is generally higher in panicle and or heading stages than the tillering stage. Even the population is out of control, there is not much loss inflicted in the rice yield, though the quality of the grain may be affected. Investigation reveals that new varieties such as IR-8 and IR-5 are more susceptible to hoppers than local varieties. For sample, serious outbreak of the pests has been found to cause heavy damage to IR-8 and IR-5 in the rice areas of Phan-Rang, Nha-Trang and Long-Xuyen

this summer.

IV. Studies on the ecology of white-back planthopper in 1968

The tropical climate and environment in Vietnam are most suitable for the multiplication of the white-back hopper, *Sogatella furcifera*. It produces up to sixteen (16) generations in a year. The degree of infestation varies from year to year, but generally it is high in wet season and low in dry and hot season. According to studies made during the year of 1968, the pest caused more damages to rice plants during the differential stage than the tillering stage, because at the latter stage, its multiplication is easily interrupted by external factors such as strong wind velocity, long sunny hours, high water level, etc. The damage of rice plants in irrigated fields where the water is usually at a low level more serious than that in ordinary fields.

V. Investigation on the population dynamics of newly-hatched nymphs of rice planthoppers

This investigation started in mid-April 1969 at the GVN Plant Protection Service aimed at determining relationship between climate and seasonal outbreak of the pests. IR-8 rice variety was used as the host plant. Nine investigations were conducted on the population dynamics of the newly-hatched nymphs. Count was made of all eggs which were completely hatched. According to the data, average number of nymphs found ranged from 4.7 to 17.8 per stem and reached a peak in mid-May. *N. lugens* were found more prevalent than *S. furcifera* probably due to climatic factors. The following table shows results of the investigations:

Population dynamics of newly-hatched nymphs of rice planthoppers, *Nilaparvata lugens* Stal, in 1969

Date of sampling rice stems	No. of rice stems surveyed	Date of newly-hatched nymphs	Hatching duration (days)	No. of hatching nymphs (total)	No. of newly-hatched nymphs/rice stem
4/14	60	14—27/IV	13	580	9.7
4/22	60	25/IV—6/V	13	442	7.4
4/30	60	4—11/V	7	284	4.7
5/ 8	60	11—20/V	9	467	7.8
5/17	60	18—25/V	8	1,070	17.8
5/28	60	28/V—3/VI	6	265	4.4
6/ 2	60	3—15/VI	8	385	6.4
6/ 9	60	10—19/VI	99	257	4.3
6/16	60	17—26/VI	9	596	9.9

IV. Studies on the evaluation of granular insecticides and foliar spray against rice planthoppers of both *N. lugens* and *S. furcifera*

The tests were conducted in the Plant Protection Service from 1968 to 1969, and were dealing with immersing method and pot method. Several kinds of granular insecticides and foliar spray were used in these tests for comparing their effectiveness against rice plant-hoppers, *S. furcifera* and *N. lugens.*

1. Methods and Materials

1968 Pot tests on nymphal stage were 12 treatments and one check. The New IR-8 variety was cultivated on June 6, in pots of 789.2 cms in size and each pot had 12 hills. The rate of application was at 1.8 kgs of active ingredient per hectare. Insecticides were applied on June 26, 20 days after transplanting, when the population density of eggs was very high. The number of newly-hatched nymphs were determined one time before treatment and 4 times after at 2-day, 13-day, 20-day, and 28-day intervals. One hill of rice plants was taken at random out of each pot with their roots free of soil. Althogether, there were 13 hills. The rice plants of each hill were then transferred into a glasscylinder set up on a large dish filled with water to keep them fresh for about a week. The number of newly-hatched nymphs every day was counted until all eggs had completely hatched. The percent control was computed by using Abbott's formula.

2. Results

According to the data, Thimet, Solvirex, Terracurp-p, Dolmix, Unden, Disyston and Lebaycid gave excellent effectiveness against newly-hatched nymphs of the white-back planthopper. The percent control of thses insecticides ranged from 94.4%-98.6%. There was no significant difference among them, but Sevidol and Ortho Buk were only less effective than others. Gamma BHC, Diazinon and Dol gave inferior rsults. Although Dol was also a gamma isomer of BHC, it was the least effective. Results are given in the following table:

Effectiveness of granular insecticides against nymphal stage of *Sogatella furcifera* at tillering stage in 1968

Treatment	Formulation	Percent control after treatment				
		2-day	13-day	20-day	28-day	Mean
Thimet	10 G	97.2	99.1	99.1	99.0	98.6
Solvirex	5 G	94.6	99.5	98.1	98.8	97.6
Terracur-P.	10 G	94.5	99.4	99.0	98.8	97.9
Dolmix	6—3 G	96.8	99.3	98.5	95.5	97.5

Unden	5 G	96.8	96.5	98.1	97.8	97.3
Disyston	10 G	91.6	99.1	99.9	99.5	96.3
Lebaycid	5 G	88.2	98.1	93.8	97.4	94.4
Sevidol and rBHC	8—8 G	94.1	97.5	85.2	77.5	88.6
Ortho Bux	6 G	33.3	81.0	84.9	91.5	72.7
Gamma BHC	6 G	70.0	94.9	75.9	22.2	65.8
Diazinon	10 G	88.8	8.8	4.8	23.5	31.3
Dol	6 G	19.5	1.5	– 33.3	58.4	11.5

3. Methods and Materials

1969 Pot tests on the nymphal stage were 13 different treatments with certain insecticides and one check in the experiments. The rice variety was the same as former trials and was cultivated into the pot on June 1.3 The size of pots was same as above ones and each pot had 7 hills. The rate of application was at 2.0 kgs of active ingredient per hectare during tillering and was at 4.0 kgs. of active ingredient per hectare during the differential stage of rice plants. The former application was on July 4, 21 days after transplanting, and the latter applicatin was on July 24, 20 days after the first application when the population density of the nymphs of this hopper was more abundant than that of the adults in each time. The number of insects one hill was determined before and after applying insecticides in each treatment. A glass vessel is used to catch insects. The top of glass vessel was filled with the tie of fine cotton to prevent the nymphs and adults from escaping. The number of insects were killed with a glass vessel in the poison bottle before counting them. The percent control of the insects was computed by using the above-mentioned method in each treatment.

4. Results

According to the percent control of the pests, Solvirex, Disyston, Diazinon, Lebaycid, S6625, Unden, Thimet, Dyfonate, Sevidol, Terrcur-p and Temik have been proven to be about equal in effectiveness against this pests, Ortho Bux was only superior to gamma BHC which was found to be the least effective against this pest as shown in the following table:

Percent control of nymphal stage of *N. lugens* after treatment in 1969

Treatment	Form-ulation	First application					Second application			Mean
		No. of nymphs					No. of nymphs			
		Before	After	% control	After	% control	Before	After	% control	
Solvirex	5 G	16	0	100.0	0	100.0	95	0	100.0	100.0
Diayston	10 G	37	0	100.0	0	100.0	45	1	98.1	99.4
Diazinon	10 G	30	0	100.0	0	100.0	74	2	97.4	99.1
Leveycid	5 G	22	0	100.0	0	100.0	56	6	96.6	98.9
S6625	5 G	45		96.2	0	100.0	89	2	93.4	96.5
Unden	5 G	22	0	100.0	1	85.4	5	0	100.0	95.1
Thimet	10 G	92	0	100.0	2	93.3	73	7	90.8	94.7
Dyfonate	5 G	19		95.5	1	98.3	104	15	86.2	93.3
Sevidol & rBHC	8—8G	44	0	100.0	1	99.3	7	2	73.2	91.1
Terracur-P	10 G	27	3	90.8	24	72.4	135	8	94.4	95.9
Temik	10 G	33	6	84.4	149	81.4	99	23	78.8	81.5
Crtho Bux	10 G	22	2	92.2	1	85.4	20	13	40.0	72.5
Gamma BHC	10 G	38	11	75.2	64	45.7	109	110	4.8	41.9
Check		30	35	—	93	—	158	164	—	—

The results revealed that population dynamics of their nymphs and adults were generally increased with exception of gamma BHC and Temik treatments, because the rice plants in these treatments were already destroyed by the hopper as well as in the untrcated pot, but the population of nymphs was still higher than that of adults in each treatment, particularly significant on September 13 and 17, 1969. The number of nymphs in Diazinon, Lebaycid and Dyfonate treatment were highest due to their residule effects being shortest among these insecticides. The symptoms of insect infestation on the rice stems slightly occurred in those treatments. The number of nymphs in S6625, Terracur-p and Sevidol treatments was only lower than above insecticides, but insect infestation of rice stems in those treatments was never found. Disyston, Solvirex, Unden and Ortho Bux have been found to be superiour over the other insecticides in controlling this pest. They limited the multiplication of the hoppers throughout the duration of rice growing in the experiments as shown in the following investigations:

Population dynamics of nymphs and adults in various treatments

Treatment	Formulation	Number fo insects per hill after treatment							
		1/IX		8/IX		13/IX		17/IX	
		Nymphs	Adults	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults
Disyston	10 G	0	5	1	1	0	0	6	3
Solvirex	5 G	19	5	0	0	0	0	13	2
Unden	5 G	10	5	0	0	0	0	24	2
Ortho Bux	10 G	4	3	2	6	67	0	34	3
Thimet	10 G	2	6	4	4	139	1	61	3
Terracur-P	10 G	2	2	6	2	140	1	103	7
S6625	5 G	33	6	9	5	121	5	119	8
Sevidol	8—8G	5	6	7	4	44	0	158	6
Diazinon	10 G	6	8	17	7	257	4	206	3
Lebaycid	5 G	20	15	14	7	294	4	251	4
Gamma BHC	10 G	—	—	—	—	—	—	—	—
Temik	10 G	—	—	—	—	—	—	—	—
Check		—	—	—	—	—	—	I	—

— =All rice stems died during survey

5. Materials and Methods

1969 Foliar spraying tests on nymphal stage were conducted with twelve kinds of insecticides as to as compare their wn effectivness against the hoppers. There was 12 different treatments and one check in the experiments. Rice variety used was the same and was cultivated into pots on July 7, 1969. Each pot had 7 hills. Insecticide spray was applied on August 20 and was repeated on September 10, when the population of nymphs was more abundant than that of adults each time. Dosage of each insecticide spray was 0.05% of active ingredient after dilution in water in each spray. The dosage of application completely covered all parts of rice plants. The process of counting the number of insects and analysing results was carried out by using the same method as mentioned above.

6. Results

The average percent control of the nymphal stage in the first application ranged from 46.7% to 99.2% and in the second application from 3.9% to 94.0%, They indicated that Brdin, Eithion, Sevin and different forms of Dimethoate were more effective in early stage of rice plants than in late stage of the crop against this pest. Unden, Ortho Bux, Barusil and Lebaycid were superior to other insecticides at various stages of rice growing. They were about equal in effectiveness. S6358, Nexion and Dipterex have been found to be the least effective against the pests. Results are given in the following

Percent control of nymphs with foliar spray in 1960

Insecticide & concentrate used at 0.05%	Formulation	First application: Percent control of nymphs after treatment				Second application: Percent control of nymphs after treatment		
		5 days	13 days	21 days	(av.)	5 days	10 days	(av.)
Bidrin	27 E.C.	80.4	91.2	97.3	89.6	43.3	– 50.8	– 3.9
Barusil	25 E.C.	55.1	78.1	77.1	70.1	96.4	74.8	85.6
S6358	25 E.C.	50.8	37.9	81.5	56.7	74.4	61.2	67.3
Nexion	25 E.C.	55.8	49.4	85.9	60.8	21.3	82.5	52.1
Dimethoate	25 E.C.	73.0	91.4	81.9	82.1	97.3	52.4	72.9
Lebaycid	50 E.C.	93.7	73.1	79.5	87.8	80.4	88.7	84.6
Ethion	44 E.C.	94.1	100.0	99.5	97.9	80.1	4.0	22.1
Ortho Bux	54 E.C.	77.4	37.9	96.0	70.4	100.0	72.0	86.0
Unden	50 W.P.	100.0	100.0	99.9	99.2	100.0	88.3	94.0
Sevin	50 W.P.	100.0	97.2	98.0	98.4	100.0	– 15.9	40.5
Dimethoate	50 W.P.	83.8	82.5	90.7	85.7	85.7	– 27.7	10.4
Dipterex	95 W.P.	30.1	52.5	57.5	46.7	31.7	– 84.0	26.3

7. Materials and Methods

1968 Tests on the egg stage were conducted twice in the greenhouse. The first series of tests were on June 25, and the second series of tests on July 15, 1968 Althogether, 12 kinds of insecticides were used to test their effectiveness against egg stage of *S. furcifera*. Samples of oviparious rice stems of each treatment were taken from outside and immersed into a glass jar of 45 cms in size containing insecticides diluted in 2,000 cc. of water. The rate of application was at 1.8 kgs. of active ingredient per hectare. Each sample consisted of 3 rice stems. These stems were kept in the jar for one day then transferred individually to glass cylinder set up on small dishes, examination and analysis were the same as the pot tests.

8. Results

The percent control of hatched eggs ranged from 37.7 to 95.3 in the twice tests. It indicated that Thimet, Lebaycid, Unden, Disyston, Dolmix, Solvirex, and Terracur-P gave excellent effectiveness in controlling this stage, there was no significant difference among them. Sevidol, Diazinon and Ortho Bux were less effective. Gamma BHC and Dol have been proven to be poor results, but Dol was the least effective one in the trials as shown in the following table:

Comparative effect of granular insecticides against egg stage at the tillering stage of rice plants in 1968

Treatment	Formulation	No. of newly hatched nymphs before treated		No. of newly hatched nymphs after treated		Percent control for ready hatched eggs		
		25/VI	25/VII	25/VI	15/VII	25/VI	15/VII	(av.)
Thimet	10 G	74	131	6	0	91.5	99.0	95.3
Lebaycid	5 G	71	149	5	5	92.8	95.4	94.1
Unden	5 G	83	160	8	3	89.9	97.9	93.9
Disyston	10 G	94	182	9	3	88.8	97.7	93.3
Dolmix	6—3 G	89	143	6	11	82.4	98.9	90.7
Solvirex	5 G	82	145	11	5	86.0	95.1	90.6
Terracur-P	10 G	90	156	10	9	86.9	91.8	89.5
Sevidol	8—8 G	53	154	7	30	89.2	72.4	80.8
Diazinon	10 G	59	154	19	5	65.6	90.8	78.2
Ortho Bux	10 G	31	126	11	13	62.9	85.4	74.2
Gamma BHC	6 G	77	133	25	45	66.0	52.7	59.4
Dol	6 G	119	138	39	97	65.7	9.7	37.7
Check (untreated)		67	146	64	103	—	—	—

9. Materials and Methods

1969 Tests on egg stage used were the dosage of active ingredient for each of 13 chemicals being 1.6 grams diluted in 2,000 cc. of water. Samples of oviparious rice stems were selected at random from rice pots in the wire-crcened cage when eggs laid on them 4 days after. The freshly-rooted rice stems of 35 days old after transplanting were immersed into the dilution of each insecticides for a duration of 5 days. These treated rice stems were then transferred into a glass cylinder placed on a small dish with water supplied every morning. The number of newly-hatched nymphs were counted 2-10 days after treatment. Also counted was the mortality of eggs by checking under dissecting microscope 10 days after.

10. Results

The relative effectiveness of these insecticides was dependent on the number of newly-hatched nymphs. It revealed that Terracur-P, Thimet, Ortho Bux Dyfonate and Solvirex were about equal in effectiveness and were superior to other ones. S6625, Diazinon, Lebaycid and Unden were sightly effective, but Cyolane was the least effective. Results are given below:

Mortality of eggs after treatment in 1969

Treatment	Form-ulation	1st Rep.		2nd Rep.		3rd Rep.		Mortality (av.)
		N o.of mortality of eggs/stem	No. of newly-hatched nymphs/stem	No. of mortality of eggs/stem	No. of newly-hatched nymphs/stem	No. of mort-ality of eggs/stem	No. of newly-hatched nymphs/stem	
Gamma BHC	10 G	x	3	x	2	x	0	—
Terracur-P	10 G	0	0	41	0	0	0	13.7
Thimet	10 G	36	0	0	0	0	0	12.0
Cyolane	10 G	0	9	58	8	44	0	34.0
S6625	5 G	41	2	36	0	16	0	41.0
Diazinon	10 G	0	2	64	0	85	0	49.7
Lebaycid	5 G	31	3	35	0	0	0	22.0
Disyston	10 G	25	0	20	0	67	1	37.5
Unden	5 G	0	2	0	0	60	1	20.0
Ortho Bux	10 G	94	0	53	0	77	0	74.7
Dyfonate	5 G	45	0	33	0	80	0	52.7
Sevidol	8—8G	x	0	x	0	x	0	—
Solvirex	5 G	44	0	22	0	24	0	30.0
Check		0	48	17	94	0	203	—

x=All rice stems died during survey.

11. Materials and Methods

1969 Tests on mature stage of nymphs were divided into two parts: First to test the residual effects of granular insecticides and second to test the accumulative effects of the insecticides.

1) The first test was dealing with 13 kinds of granular insecticides to find out their effectiveness against the mature stage of nymphs of *N. lugens*. The dosage of the insecticides used was the same as above method. Samples of rice stems used were 35 days old after sowing in the pots. Every 3 rice stems was immersed into the dilution for 32 hours before transferred into the glass cylinders which were placed on the small dishes. Inoculations of mature nymphs were made in 3 times–30 hours, 54 hours and 126 hours afterwards. The mortality of nymphs was counted 19 hours later after each inoculation.

12. Results

The relative residual effects of the insecticides may be arranged in the order as shown below:

Comparative effect of granular insecticides against egg stage at the tillering stage of rice plants in 1968

Treatment	Form-ulation	No. of newly hatched nymphs before treated		No. of newly hatched nymphs after treated		Percent control for ready hatched eggs		
		25/VI	25/VII	25/VI	15/VII	25/VI	15/VII	(av.)
Thimet	10 G	71	131	6	0	91.5	99.0	95.3
Lebaycid	5 G	74	149	5	5	92.8	95.4	94.1
Unden	5 G	83	160	8	3	89.9	97.9	93.9
Disyston	10 G	94	182	9	3	88.8	97.7	93.3
Dolmix	6—3G	89	143	6	11	82.4	98.0	90.7
Solvirex	5 G	82	145	11	5	86.0	95.1	90.6
Terracur-P	10 G	90	156	10	9	86.9	91.8	89.5
Sevidol	8—8 G	53	154	7	30	89.2	72.4	80.8
Diazinon	10 G	59	154	19	5	65.6	90.8	78.2
Ortho Bux	10 G	31	126	11	13	62.9	85.4	74.2
Gamma BHC	6 G	77	133	25	45	66.0	52.7	59.4
Dol	6 G	119	138	39	97	65.7	9.7	37.7
Check (untreated)		67	146	64	103	—	—	—

2) The second test was the same as above one except that rice stems were immersed into the dilution of each chemical for a duration of 21 hours before transferred into the glass cylinder. Mortality of the number of mature nymphs was counted at intervals of 4 hours, 48 hours and 72 hours.

13. Results

The percentage of mortality was particuarly high-ranged from 20.0 to 97.1%when counted 48 hours after inoculation as compared with 16.0% in check. With exception of Cyolane, Diazinon and gamma BHC, all insecticides seem to have equally accumulative toxicity in this stage as shown in the following table:

Accumulative toxicity of various chemicals in controlling nymphs in mature stage

Treatment	Formulation	No. of nymphs inoculated	Percentage of nymphs in mature stage			
			4-hours after inoculated %	48-hours after inoculated %	72-hours after inoculated %	Mortality % (Total)
Terracur-P	10 G	85	16.5	83.5	0	100.0
Thimet	10 G	116	16.4	82.0	1.6	100.0
S6625	5 G	86	12.8	83.7	3.5	100.0
Ortho Bux	10 G	87	15.0	85.0	0	100.0
Dyfonate	5 G	101	12.9	87.1	0	100.0
Solvirex	5 G	84	21.6	78.4	0	100.0
Disyston	10 G	114	13.2	85.1	0	98.8
Sevidol	8—8 G	89	16.5	82.3	0	98.8
Unden	5 G	97	22.7	69.8	0	92.5
Lebaycid	5 G	86	20.9	74.4	3.5	98.8
Gamma BHC	10 G	82	15.9	44.6	8.5	69.0
Diazinon	10 G	115	13.2	21.1	29.0	63.3
Cyolane	10 G	105	17.6	20.0	9.5	47.1
Check		85	14.7	16.0	0	30.7

VII. Summary

The seasonal outbreak of the rice borers, leafhoppers and planthoppers is generally associated with climatic weather and environmental conditions. According to the ecological environment of these pests in Vietnam, the relative outbreak and their damage made to rice plants is concerned with the basic environmental conditions which are more important than weather throughout the year, wheras their infestation of rice plants in central Vietnam is more serious than in Southern Vietnam. Especially the outbreak of the leafhoppers, *Nephotettix* spp., and planthoppers, *Nilaparvata lugens* and *Sogatella furcifera* is more abundant than that of the rice borers, namely, *Tryporyza incertulas*, *Chilo suppressalis*, and *Sesamia inferens*. The new varieties of IR-5 and IR-8 are more susceptible to these pests than local varieties. The damage of rice plants in irrigated fields is more serious than that in ordinary fieldss where the water level is usually high.

Several kinds of granular insecticides were tested against various stages of *N. lugens* and *S. furcifera*, namely, egg, newly-hatched nymphs and mature nymphal stages. All granular insecticides with exception of gamma BHC, Temik, Cyolane, Diazinon and Sevidol were all effective against these stages. The relative effectiveness of the insecticides under discussion appeared to have been more or less influenced by their own residual effect and

varied in different stages of the hoppers.

Foliar spray was tested with twelve kinds of insecticides in the mature stages of nymphs. Bidrin, Ethion, Sevin and different forms of Dimethoate have been found to be effective in tillering stage of rice plants for controlling the pests. Unden, Ortho Bux, Barusil and Lebaycid were superior to other ones in controlling the pests in various stages of rice growing. They were about equal in effectiveness. However, S6358, Nexion and Dipterex have been found to be the least effective against the pests.

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1968-1969越南稻作害蟲之研究報告

摘　要

陶家驊*　吳定秀**

越南水稻螟蟲，稻葉蟬類及稻飛蝨類等之發生對於季節氣候與環境均有相互密切之關係，按其在越南發生環境，據筆者研究結果，其蔓延猖獗之趨勢，認為環境因子較氣候因子尤為重要。因此，中越水稻區以適宜蔓延滋生，而構成嚴重之災害時有所聞。但湄公河三角洲水稻區之環境，鮮有聞其為害成災者。在稻作害蟲中以黑尾葉蟬 (*Nephotettix spp.*) 及褐飛蝨 (*Nilaparvata lugens*) 及白背飛蝨(*Sogatella furcifera*) 為害較螟蟲熾烈。螟蟲包括：一點螟蛾 (*Tryporyza incertnlas*) 條化螟 (*Chilo suppressallis*) 紫螟 (*Sesamia inferens*) 等。稻飛蝨類之為害水稻品種間，亦有顯著差異，其中以 IR—8 及 IR—5 等品種遭其為害較當地品種慘重。

粒狀劑防治褐飛蝨 (*N. lugens*) 及白背飛蝨 (*S. furcifera*) 等卵期，甫孵化之若蟲及老熟之若虫等期，其中除RIBHC, Temik, Diazinon & Sevidol 外均獲顯著成效。至於有關防治成果，亦顯有差別，其中首推藥劑間殘效作用時間及飛蝨類生育不同時期而影響互異。

殺蟲劑噴射試驗防治褐飛蝨之老熟若蟲時期，各藥劑間防治效果，對於水稻生育不同時期，亦有顯著差異，例如 Bidrin, Ehtion & Sevin 及不同性狀之 Dimethoate 均在水稻分蘗時期防治褐飛蝨之老熟若蟲期最有效，但在水稻孕穗及抽穗兩期無效 Unden, Ortho Bux, Barusil & Lebaycid 防治褐飛蝨老熟若蟲期，無論在水稻分孕穗及抽穗期均獲相似成果。偶有在水稻期防治成效上略有差異，對於各藥劑間殘餘作用，頗有相互密切之關係，甚至於水稻生育不同時期，亦有互相密切之關係。茲據本試驗結果顯示 S6538, Nexion 及 Dipterex 等防治成效最劣。

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